Eng. Lib.

GENERAL LIBRARY,
UNIV. OF MICH.
DEC 24 1907

SCIENTIFIC AMERICAN SUPPLEMENT. No. 1669

Entered at the Post Office of New York, N. Y., as Second Class Matter.
Copyright, 1907, by Munn & Co.

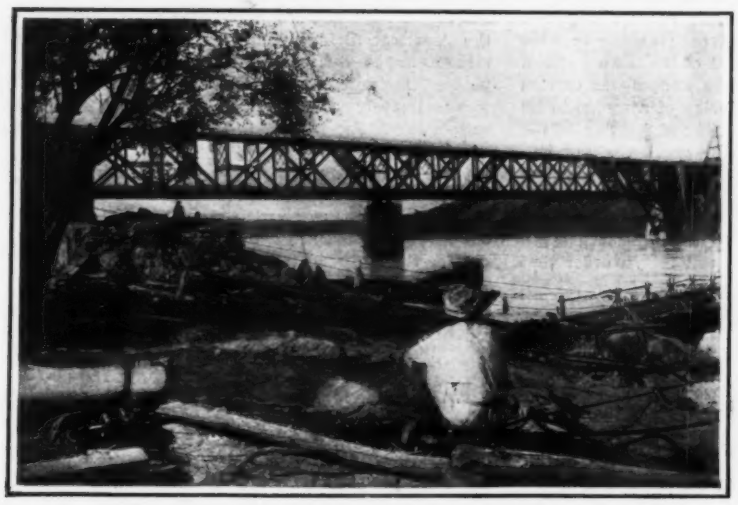
Published weekly by Munn & Co. at 361 Broadway, New York.

Charles Allen Munn, President, 361 Broadway, New York.
Frederick Converse Beach, Sec'y and Treas., 361 Broadway, New York.

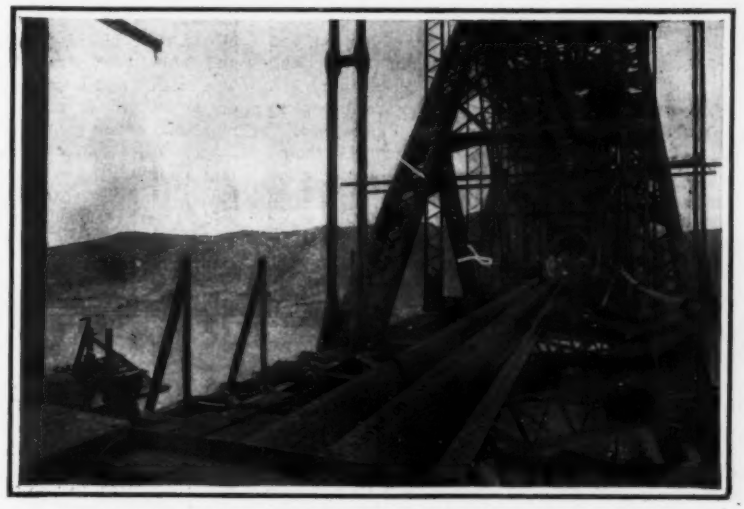
Scientific American, established 1845.
Scientific American Supplement, Vol. LXIV., No. 1669. NEW YORK, DECEMBER 28, 1907. Scientific American Supplement, $5 a year.
Scientific American and Supplement, $7 a year.

SOME OF THE LABOR RECRUITED LOCALLY FOR ERECTING THE BRIDGE.

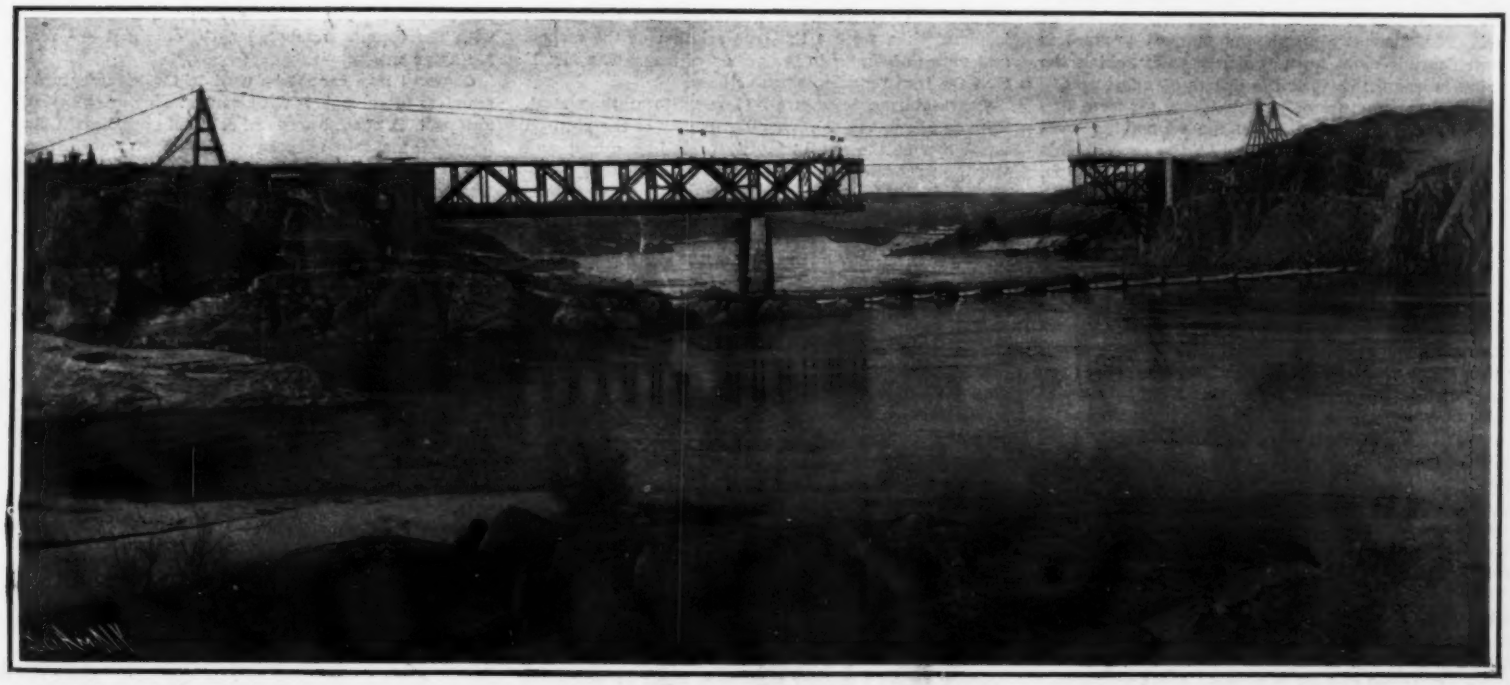
THE TRAFFIC HIGHWAY WITH THE RAILROAD TRACK ABOVE.



THE BRIDGE JOINED FROM BANK TO BANK AND NEARING COMPLETION.



THE LOWER DECK DURING CONSTRUCTION, SHOWING THE PRESSED TROUGHING FOR FLOOR.



THE BRIDGE DURING CONSTRUCTION, SHOWING THE ANCHOR ARM AND THE CANTILEVER LEGS. THE AERIAL RAILWAY AND THE PROTECTIVE NET ARE SHOWN, AND IN THE FOREGROUND IS THE BRIDGE OF BOATS ACROSS WHICH LOCAL TRAFFIC HAS HITHERTO GONE.

AN INDIAN CANTILEVER BRIDGE ACROSS THE INDUS.

AN INDIAN CANTILEVER BRIDGE.

A STRUCTURE BUILT ENTIRELY BY NATIVE LABOR.

BY THE ENGLISH CORRESPONDENT OF THE SCIENTIFIC AMERICAN.

AN interesting engineering achievement has recently been completed in India by the spanning of the River Indus at Khusalgarh with a double-deck steel cantilever bridge. For some years past the necessity for some efficient means of communication between the opposite banks, other than that offered by a primitive pontoon bridge, has been emphasized, its absence being especially felt by the Northwestern Railroad Company, whose freight had to be conveyed from bank to bank by means of an aerial railroad, the pontoon structure being reserved for lighter highroad traffic. But the bridging of the river presented difficulties, since the bed of the main channel drops sheer down on either side to a depth of 210 feet and 160 feet below low water level respectively, while the width of the waterway varies from 310 feet at low water to 800 feet when in flood, the rise and fall between the two levels being approximately 50 feet. At this point, moreover, the river runs through a rocky gorge, the main channel of the river being practically resolved into a deep chasm. Under these circumstances, as a pier could not be erected in the middle of the river, the main span would have to be over 450 feet in length, and a cantilever design became necessary.

The structure is designed to carry railroad, pedestrian, and vehicular traffic, the former being carried upon the upper deck, and the others upon the lower deck, the depth of the trusses being governed by the respective levels of the two systems of traffic. The bridge has an over-all length of 774 feet, and is divided into two sections—an anchor arm 303 feet long on the eastern bank, and a cantilever span over the main channel 471 feet in length, comprising two cantilever arms each 104 feet 8 inches in length, and a slung span of 261 feet 8 inches. The structure was designed by Messrs. Rendel & Robertson, of London, and constructed by the Tees Side Bridge and Engineering Works of Middlesbrough under the direction of Mr. J. E. Swanker, M.Am. Soc.C.E., to whose courtesy we are indebted for these particulars and illustrations.

The general features of the design may be gathered from the accompanying illustrations. The main girders are spaced at 20 feet centers, while the depth from center to center of chords is 45 feet. Along the upper deck extends a single track of 5 feet 6 inches gage, carrying the Northwestern Railroad across the river, the track being carried by stringers resting on cross girders 3 feet in depth. The highroad traffic is carried upon the lower deck some 45 feet below, the roadway being laid on longitudinal pressed steel troughing at 15 inches depth resting on 3 feet deep cross girders at each panel point. Owing to the difficulties in handling the constructional material at the site, all the pieces were purposely kept as light and convenient as possible, the largest section only weighing about 5 tons.

As the eastern bank of the river is exposed during low water, it was found possible to erect the anchor arm on staging, the height of which was approximately 70 feet, but the cantilever section was built out from either end, one-half of the suspended span being built out from either cantilever arm and a junction effected in the center. An aerial ropeway was thrown across the river, by means of which the material was transported from the railroad cars to the point of erection. Building was carried out exclusively by native labor, there being only about half a dozen white men engaged as superintendents.

On the western bank the two cantilever legs spring from two cast-iron pedestals imbedded in concrete. The legs, which at the level of the lower truss of the bridge are spaced 20 feet apart, spread out to 40 feet center to center at their bases. As the river when in flood often rises considerably above the level of the anchoring pedestals, a collision strut has been placed about 15 feet above the base, in order to strengthen the legs against damage from floating debris brought down by the water. To facilitate the junction of the cantilevers in the center, and to effect any adjustments that might become necessary in the chord lengths, cast-iron wedges working against cast-steel blocks were placed just behind each cantilever nose and behind each suspension point of the bottom chord. The raising and lowering of these wedges was carried out by worm gear, and the lowering of a wedge to its maximum extent gave a lengthening of 3 inches to the top chords, or a corresponding shortening of the bottom chords. Immediately the junction of the two halves of the suspended span was completed, these wedges were removed, thereby permitting sliding movements to take place at the nose of the eastern cantilever and in its bottom chord section. In order that the cantilever expansions should be confined to these points, directly the wedges were withdrawn, a central pin connection of the flooring of the lower chords of the first and second outer panels of the western cantilever was made to the cross girder of the latter panel, and the stress here set up by the resistance to expansion is distributed to the bottom chord system of the west cantilever by specially stiffened floor plates. Wind shear stresses in the bottom section of the slung span are thus taken up at this spot without any communication of direct stress along the chords at this point. By this arrangement practically no expansion takes place at the nose of the western cantilever. At the nose of the eastern cantilever and at the east abutment of the bridge there is a special expansion rail capable of extending 6¾ inches.

A sliding bearing carries the end stringers on the east and west abutments. At the eastern abutment is a knuckle bearing with a roller slide, while on the other hand the knuckle bearings on the central pier are practically fixed. In order, however, to avoid the splitting action on the pier which would result from the dissimilar deflections of the two spans by wind, the knuckles which have circular bases are mounted in such a way that one can rotate and the other slide backward and forward to the extent of one inch in either direction. The last-named is placed at the side toward the direction from which the strongest wind prevails, while the rotating disk is away from that point. At the west abutment the vertical end posts are pin-connected at both ends.

The bridge was constructed throughout at the works of the builders with the exception of the eyebars by means of which the west cantilever is anchored and the suspended span is slung, and these were prepared by the American Bridge Company. The erection of the structure was carried out with great rapidity and without incident, despite the fact that native labor was exclusively employed; this labor proved eminently satisfactory. For the protection of the laborers while engaged on the span, nets were suspended beneath the bridge, in order to catch workmen, tools, etc., which fell, these nets being carried on cables slung from the river pier to the western shore. The abutments on either side are of masonry, with special approaches laid out for the highroad traffic over the lower deck.

MANUFACTURE OF BOILER TUBES.*

A METALLURGICAL PROBLEM.

BY F. N. SPELLER.

ALL processes for recovering iron from its ore have the first operation in common in that the blast furnace is used to obtain a crude iron carrying about 5.6 per cent of foreign matter, which is afterward removed by further refining until we have commercial iron or steel. The name by which the finished product is known depends more upon the process by which the refining is completed, than the degree of refinement.

For the manufacture of welded tubes, we were limited to charcoal iron until the art of making weld steel was sufficiently developed. At the present this steel gives better results in welding than wrought iron, and by a special process of mechanical working which we apply at or near a welding heat the texture is made compact and fine and the life of the tubes increased. The principal characteristic of charcoal iron, not possessed by steel, is the presence of 1 to 2 per cent of cinder. This cinder acts as a flux to carry away impurities in the raw iron, but a certain amount remains entangled in the ball of refined iron when it is withdrawn from the forge. Subsequent hammering only partially removes this cinder. Microscopic photographs of cross sections of iron and steel plates show the distribution of the cinder in wrought iron and the comparative unbroken granular section of the steel. It will be observed that there is no relation between the grains of iron and the cinder and that the iron is just as granular as the steel. It is the presence of this cinder that gives iron its fibrous appearance when broken, the fibers being not iron but strings of cinder which have no strength in themselves and only serve to break up what would otherwise be a continuous and uniform granular structure. In other words, weld steel may be considered as highly refined iron freed from cinder. Charcoal and other wrought irons are finished in a pasty state and retain a certain amount of cinder imprisoned in the mass, while soft steel is finished in a molten condition, which permits the cinder, in virtue of its lightness, to rise and float on top of the molten metal.

An erroneous idea has been spread abroad that the grains of iron are "enveloped" in cinder and thus protected from corrosion. The fallacy of this argument is plain when we see the true relation of the strings and plates of cinder to the grains of iron. The fact is that the iron "envelopes" the cinder.

Charcoal iron is naturally less uniform than steel, first, on account of the irregular quality of the pig iron used; second, the small quantity made in one heat, and third, on account of the large factor of personal attention and skill required on the part of operator. It is becoming more and more difficult to secure sufficient high-class men for this work, for although wages have been advanced materially, men of the necessary intelligence can usually do better at other work of a less strenuous character.

Lap weld boiler tubes are made by first scarifing the edges of the plate and then drawing through a die so shaped as to lap the edges over about ⅜ of an inch. The skelp is next pushed into a welding furnace heated to the required temperature and passed through a set of rolls. Between these rolls a ball is held in position by means of a stout rod over which the tube passes on leaving the furnace. Boiler tubes are given two heatings and two passes through these rolls at a welding heat by which the lapped surfaces are firmly pressed together and united. The tube is finished by passing through a similar set of rolls slightly smaller in diameter and without a ball inside, and then straightened in cross rolls and slowly cooled. The ends which have to stand working are annealed at a bright orange to reduce the grain caused by the welding heat, thereby giving a greater margin of safety in expanding and rolling. After welding and cooling, the rough ends cut off the tubes are crushed down flat with the weld on the side. If no sign of opening of the seam appears, the tube passes on to the inspectors, and if free from surface defects, is subjected to the specified hydraulic tests, usually 600 pounds per square inch. Samples are taken from time to time through the day on which standard M. M. tests are made. If the tubes stand this inspection and testing successfully they are marked with the tester's number, length, etc., and are ready for shipment.

Charcoal iron cannot be used in the manufacture of seamless tubes, as it is not strong enough or sufficiently uniform. A special grade of selected open hearth steel is made for this purpose, containing about 0.17 per cent carbon and 99.3 per cent iron. The carbon is low enough to permit of welding without difficulty, although the grade of steel made for lap welding, which contains considerably less than this amount of carbon, is naturally somewhat easier to weld. The steel is first rolled into round bars about 2¾ to 3 inches in diameter by 30 to 40 inches long. These are heated and pierced in a mill to a rough tube 2¾ to 3 inches in diameter by 5-16 inch wall and 7 to 8 feet long. The disks of the piercing machine lie in parallel planes and are mounted on the ends of shafts, the axial lines of which are also parallel and lie in the same horizontal plane. The disks revolve in the same direction, so that the round billet passed between them in contact with their opposing surfaces has imparted to it a rotary movement, and if the blank is passed between the disks, either slightly above or below the plane of their axes, it has imparted to it a longitudinal movement also. The next operation after reheating consists in passing the pierced piece successively through rolls somewhat similar to those used in lap welding, with a mandrel to maintain the inside diameter. The ends of the partially finished tubes are now "pointed" or hammered down preparatory to cold drawing. After each draw through the die the tube is annealed and pickled clean, the final operation being a thorough annealing. The tests applied to seamless tubes are the same as those described for welded tubes.

* From a paper recently read before the Richmond Railway Club.

THE PROBLEM OF THE METALLIFEROUS VEINS.*

A GEOLOGICAL QUESTION.

BY JAMES FURMAN KEMP.

OF all the metals the most important which minister to the needs of daily life are the following, ranged as nearly as possible in the order of their usefulness: Iron, copper, lead, zinc, silver, gold, tin, aluminium, nickel, platinum, manganese, chromium, quicksilver, antimony, arsenic, and cobalt. The others are of very minor importance, although often indispensable for certain restricted uses.

The manner of occurrence of these metals in the earth and their amounts in ores which admit of practicable working are fundamental facts in all our industrial development, and some accurate knowledge of them ought to be a part of the intellectual equipment of every well-educated man. The matter may well appeal to Americans, since the United States has developed within a few years into the foremost producer of iron, copper, lead, and, until recent years, of gold and silver; but, with regard to gold, they have of late alternated in the leadership with the Transvaal and Australia, and in silver are now second to Mexico.

We may best gain a proper conception of the problem of the metalliferous veins if we state at the outset the gross composition of the outer portion of the globe, so far as geologists have been able to express it by grouping analyses of rocks. We may then note among the elements mentioned such of the metals as have just been cited, and may remark the rarity of the others; we may next set forth the necessary percentages of each metal which make a deposit an ore; that is, make it rich enough for profitable working. By comparison, we can grasp in a general way the amount of concentration which must be accomplished by the geological agents in order to collect from a naturally lean distribution in rocks enough of a given metal to produce a deposit of ore, and can then naturally pass to a brief discussion and description of those agents and their operations.

If the general composition of the crust of the earth is calculated as closely as possible on the basis of known chemical analyses, the following table results, which has been compiled by Dr. F. W. Clarke, of Washington, chief chemist of the United States Geological Survey:

	Per cent.		Per cent.
Oxygen	47.13	Manganese	0.07
Silicon	27.89	Sulphur	.06
Aluminium	8.13	Barium	.04
Iron	4.71	Chromium	.01
Calcium	3.53	Nickel	.01
Magnesium	2.64	Strontium	.01
Potassium	2.35	Lithium	.01
Sodium	2.68	Chlorine	.01
Titanium	.32	Fluorine	.01
Hydrogen	.17		
Carbon	.13	Total	100.00
Phosphorus	.09		

Elements less than 0.01 per cent are not considered abundant enough to affect the total, and equally exact data regarding them are not accessible. Among those given only the following appear which are metals of importance as such in everyday life: Aluminium 8.13, iron 4.71, manganese 0.07, chromium 0.01, and nickel 0.01. They rank, respectively, in the table, third, fourth, thirteenth, sixteenth, and seventeenth. Of the five, iron is the only one of marked prominence. No one of the remaining four is comparable in usefulness with at least five other metals which are not mentioned, viz., copper, lead, zinc, silver, and gold.

In order to come within the possible limits of profitable and successful treatment the ores of the more important metals should have at least the following percentages, but that we may grasp the relations correctly it must be appreciated that local conditions affect the limits. Thus in a remote situation and with high charges for transportation an ore may be outside profitable treatment, although it may contain several times the percentages of those more favorably situated. Iron ores in particular which are distant from centers of population are valueless unless cheap transportation on a very large scale can be developed, while gold in an almost inaccessible region, like the Klondike, may yield a rich reward, even when in quantities which, if expressed in percentages, are almost inappreciable.

The nature of the ore is also a factor of prime importance. Some compounds yield the metals readily and cheaply, while others, which in the case of the precious metals are often called base ores, require complicated and it may be expensive metallurgical treatment. The association of metals is likewise of the highest importance. Copper or lead, for example, greatly facilitates the extraction of gold and silver, whereas zinc in large quantities is a hindrance. Conditions also change. An ore which may have been valueless in early days may prove a rich source of profit in later years and under improved conditions. For instance, from 1870 for over twenty-five years Bingham Cañon in Utah yielded lead-silver ores and minor deposits of gold. It was known that in some mines low-grade and base ores of copper and gold existed, but the fact was carefully concealed, and in at least one instance the shaft into them was filled up, lest a general knowledge of the fact should unfavorably affect the value of the property. To-day, however, these ores are eagerly sought and their extraction and treatment in thousands of tons daily are paying good returns on very large capitalization. Another factor is the expense of extraction. If simple and inexpensive methods are possible, the area of profitable treatment is greatly widened. Thus gold may need little else than a stream of water or even a blast of air, whereas iron and copper require huge furnaces and vast supplies of coke and fluxes.

Iron ores are of little value in any part of the world unless they contain a minimum of 35 per cent iron when they enter the furnace, but if they are distributed in amounts of 10 to 20 per cent in extensive masses of loose or easily crushed rock in such condition that they can be cheaply concentrated up to rich percentages, they may be profitably treated and a product with 50 per cent iron or higher be sent to the furnaces. Nevertheless, speaking for the civilized world at large, it holds true that as an iron ore enters the furnace it cannot have less than 35 per cent, and in America, with our rich and pure deposits on Lake Superior, two-thirds of our supply ranges from 60 to 65 per cent.

As regards copper, a minimum working percentage amid favorable conditions and with enormous quantities is usually about 3 per cent, but in the altogether exceptional deposits of the native metal in the Lake Superior region copper rock as low as three-fourths of 1 per cent has been profitably treated. This or any similar result could only be accomplished with exceptionally efficient management and with a copper rock such as is practically known only on Lake Superior. With the usual type of ore, not enriched by gold or silver, 2 per cent is the extreme, and in remote localities 5 to 10 may sometimes be too poor.

In southeast Missouri lead ores are profitably mined which have 5 to 10 per cent lead, but they are concentrated to 65 to 70 per cent before going to the furnace.

Zinc ores at the furnace ought not to yield less than 25 to 30 per cent, and when concentrated or selected they range up to 60 per cent.

The precious metals are expressed in troy ounces to the ton avoirdupois. A troy ounce in a ton is one three-hundredth of 1 per cent, and the amount is therefore very small when stated in percentages. If it be appreciated that in round numbers silver is now worth 50 to 60 cents an ounce and gold $20, some grasp may be had of values. Silver rarely occurs by itself. On the contrary, it is obtained in association with lead and copper, and the ores are, as a rule, treated primarily for these base metals and then from the latter the precious metals are later separated. In the base ores there ought to be enough silver to yield a minimum of $5, or 10 ounces, in the resulting ton of copper in order to afford enough to pay for separation. Now, in a 5 per cent ore of copper we have a concentration of 20 tons of ore to yield 1 ton of pig, or more correctly stated, so as to allow for losses, 21 tons to 1. We must therefore have at least 10 ounces of silver in the 21 tons, which implies a minimum of about one-half ounce per ton. Smelters will only pay a miner for the silver if he has over one-half ounce per ton in a copper ore. In a pig of lead, usually called base bullion, it is necessary for profitable extraction to have 15 ounces of silver. For smelting a lead ore we must possess at least 10 per cent lead and may have 70. It is therefore obvious that from 2 to 20 ounces of silver must be present in the ton of lead ore. The common ranges are 10 to 50 ounces, or one-thirtieth to one-sixth of 1 per cent.

Gold is so cheaply extracted that it may be profitably obtained under favorable circumstances down to one-tenth of an ounce in the ton, but the run of ores is from one-fourth ounce, or $5, to 1 ounce, or $20. Ores, of course, sometimes reach a number of ounces. In copper or lead ores even a twentieth of an ounce may be an object, and in favorably situated gravels to which the hydraulic method may be applied even as little as 7 to 10 cents in the cubic yard may be recovered, or some such value as when one two-hundredth to one three-hundredth of an ounce per ton.

The tin ores as smelted contain about 70 per cent, but they are all concentrated either by washing gravels in which the percentage is one or less, or else by mining, crushing, and dressing ore in which it ranges from 1.5 to 3 per cent. The tin-bearing gravels represent a concentration from much leaner dissemination in the parent veins and granite. Aluminium ores yield as sold about 30 per cent of the metal. This is an enrichment as compared with the rocks, though not so striking a one as in the case of other metals. But the great change necessary in aluminium is in the method of combination. It is so tightly locked up in silicates in the rocks as to preclude direct extraction by any known method.

Nickel needs to be present in amounts of several per cent, say 2 to 5, and occurs either alone or with copper. Cobalt is always with it in small amounts. Platinum occurs in exceedingly small percentages. It is almost all obtained from gravels in Russia, and the gravels yielded in 1899, according to C. W. Purington, about 40 cents to the yard, platinum being quoted in that year at $15 to $18 per ounce. There was, therefore, in the gravels about one-fortieth ounce in the yard, or one-sixtieth in a ton, or about five and a half hundred thousandths of a per cent. Platinum in some rocks has been found in amounts of one-twentieth to one-half ounce, or from sixteen hundred thousandths to sixteen ten thousandths of 1 per cent, but they are rare and peculiar types.

In order to be salable, manganese ores of themselves must yield about 50 per cent, but if iron is also present they may be as low as 40. Chromium has but one ore, and it must contain about 40 per cent. Of antimony, arsenic, and cobalt, it is hardly possible to speak, since, except perhaps in the case of the first, they are unimportant by-products in the metallurgy of other ores.

We now have before us some fundamental conceptions from which as a point of departure we may set out upon the real discussion of the subject. We understand the gross composition of the outer earth; we have some idea of the quantitative distribution of the metals in the rocks, especially in the richer instances; finally we have seen the extent to which they must be concentrated in order that they may be objects of mining. The next step is to establish, first, the agent or solvent which can effect the collection of the sparsely distributed metals, and second, the places where the precipitation of them takes place. We may then inquire more particularly into the source of the agent and the methods of its operation. In order to do this in the time at command, I must remorselessly focus attention on the large and essential features, resolutely avoiding every side issue or minor point, however inviting.

The one solvent which is sufficiently abundant is water, and practically all observers are agreed that for the vast majority of ore deposits it has been the vehicle of concentration. Of course it need not operate alone. On the contrary, easily dissolved and ever-present materials like alkalies may, and undoubtedly do, increase its efficiency. It does not operate necessarily as cold water. On the contrary, we all know that the earth grows hotter as we go down, so that descending waters could not go far without feeling this influence.

Volcanoes, too, indicate to us that there are localities where heat is developed in enormous amounts and not far below the surface. There is therefore no lack of heat, and we need only be familiar with the western country to know that there is no lack of hot springs when we take a comprehensive view. As solvents, hot waters are so incomparably superior to cold waters that they appeal to us strongly. We may therefore take it as well established that water is the vehicle. The chemical compounds which constitute the ores naturally differ widely in solubility, and no sweeping statements can be made regarding them. Iron, for example, yields very soluble salts and is widely, one might almost say universally, distributed in ordinary waters. Its ores are compounds of the metal with oxygen and in this respect it differs from nearly all others, which are mostly combined with sulphur. Although almost all of them have oxidized compounds, the latter are on the whole very subordinate contributors to our furnaces.

Iron is everywhere present in the rocks, and when exposed to the natural reagents it is one of their most vulnerable elements. It therefore presents few difficulties in the way of solution and concentration by waters which circulate on or near the surface and which perform their reactions under our eyes.

(To be continued.)

* From a presidential address before the New York Academy of Sciences.

MOLDING BY THE USE OF A GROUP OF CORES.

A METHOD IN WHICH SEVERAL CASTINGS ARE POURED TOGETHER.

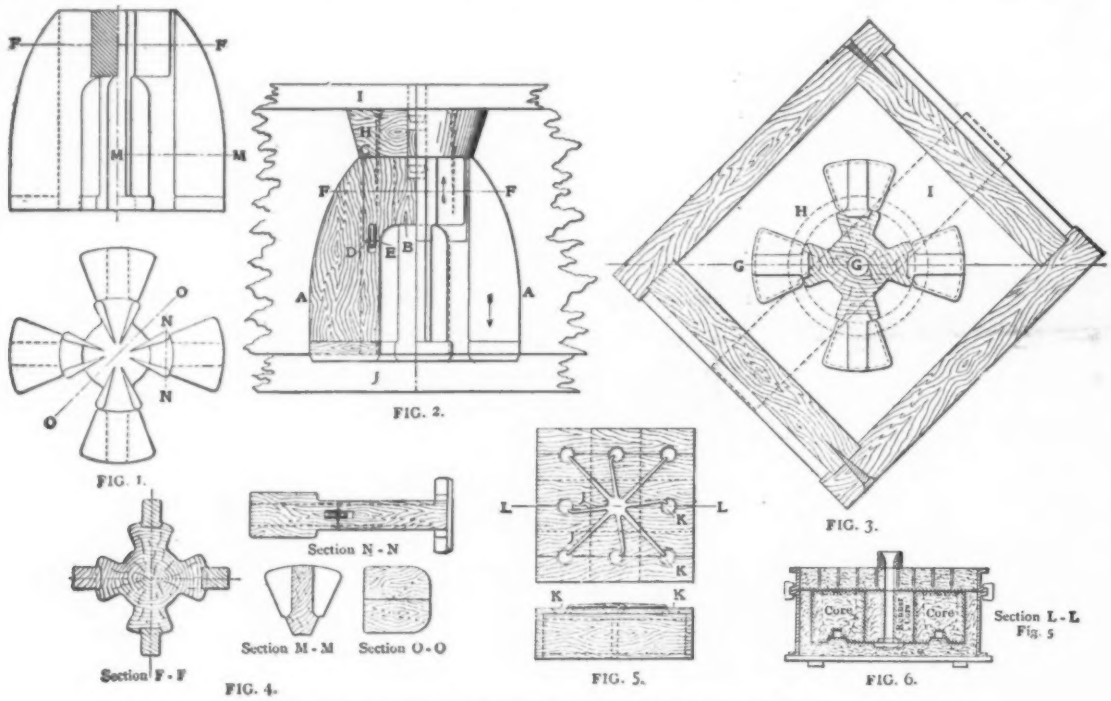
BY H. J. M'CASLIN.

WHEN intricate castings are to be made and the number is not sufficient to warrant the fitting up of a molding machine, particularly in the production of small steel castings, where the facilities for pouring such molds are not in accord with the requirements, a large 10 or 20-ton stopper pouring ladle being used, group or multiple-core molding may be resorted to with very good results, especially where it is desired to use dry-sand molds.

As the name implies, the process consists of the grouping or stacking together of a number of cores containing impressions of the object to be cast, and having the runner and gates so arranged that they may be poured collectively.

A spring jacket casting, as illustrated in two views, Fig. 1, not only serves as an excellent object to be molded in this manner, but affords a good example of producing a casting free from fins and true to pattern, without a more intricate and expensive mold, as the various disadvantages and difficulties that would be encountered if molded in any other manner will be readily appreciated.

To obtain a better idea of the molding, let us discuss the arrangement of the pattern so as to permit its withdrawal from the sand subsequent to the removal of the core box or frame.



MOLDING BY THE USE OF A GROUP OF CORES.

While Fig. 1 shows side elevation and inverted plan of the casting, it also gives the position of the planes of the various sections of the pattern shown in Fig. 4. The casting consists of a hub with four supports or legs. Fig. 2 is a half elevation, also a half longitudinal section of the completed or assembled pattern on the line *G G*, Fig. 3. The latter figure is a plan view of the pattern as it would appear within the core box, with the cleat *I* shown in dotted lines removed.

The pattern proper consists of the hub *B*, Fig. 2, to which is attached the conical core print *H*. The four supports or legs *A*, being joined and pinned together along the line *C D E*, form the shoulder *D E*. This manner of parting the pattern allows the supports *A* to be drawn from the sand in the direction indicated by the arrow, that is, in the opposite direction to that of the core print and hub *B* and *H*. *J* indicates a depression in the bottom board of the box corresponding to projections on the supports *A*, to receive and locate these four parts of the pattern in their correct position in the core box.

Fig. 4 gives four sections of the assembled pattern, showing more fully the manner of fitting and securing the various parts together.

The core box or frame simply consists of a rectangular frame with bottom board. The frame must be of sufficient depth to allow ample sand above the pattern, say 2¼ inches, which of course is the same thickness or height as the core print *H*, Fig. 2.

The frame having been placed upon the bottom board, the supports *A* of the pattern are placed into the depressions in the bottom board made to receive them, and the hub *B*, with the core print *H* attached, is dropped into place upon the supports *A*. To secure the pattern and prevent its being rammed out of place, cleat *I*, shown in dotted lines in Fig. 3, is attached to the top of the box and by the aid of a dowel pin engages the core print *H*.

The box having been clamped together, it is rammed to the top and struck off in the usual manner. Cleat *I* is next removed, and core print *H* and hub *B* drawn out in the direction indicated by the arrow. The box is now rolled over, the bottom board removed and the four supports *A* drawn independently. If desired, the core can be given a light wash, being put into the oven and thoroughly dried.

To form a bed or depression within which to set the cores for casting, a box or block, as shown (on a smaller scale) in Fig. 5, is employed. In the case under discussion the casting is done in groups of nine cores—eight cores containing an impression of the object to be cast and one core containing the runner. This arrangement would require a block or box with an area equivalent to nine cores and in thickness equal to the height of the cores; of course allowance must be made for the swelling and roughness of the cores.

The construction of the block is accomplished by nailing or screwing together to form a closed box of the desired area, and in height equivalent to the height of the pattern. Upon one side of the block, lay off the outlines of the number of cores to be used, as shown in dotted lines, Fig. 5. Blocks are now gotten out, having an area equal to the squares laid off, and in thickness equivalent to the height of the core print *H* in the core box; the holes *K* are turned at their center to conform to the core print *H*, but of a slightly smaller diameter, say 1-16 inch. The blocks *K* are then carefully located and secured to the main block. Some patternmakers might prefer to cut these holes out of a board of the desired thickness and size of the molding block; however, I find it more convenient to turn them out of separate pieces and secure them in place.

Arranging the gates *J* as shown in Fig. 5 now takes our attention. Care should be exercised in placing the gates, in order that the metal shall enter the mold directly under one of the depressions left vacant by one of the supports *A*.

This part of the work is a good job for the apprentice, as it requires very little if any skill. The block, as shown in Fig. 5, having been placed upon a bottom board with the gating upward, a flask is placed over it; it receives the usual ramming up and rolling over of the flask as with the molding of ordinary patterns. Parting sand is next applied and the cope rammed up with the runner stick in place. The cope is lifted off, the block drawn and the setting of the cores is next in order.

Fig. 6 gives a cross-section of the completed mold on the line *L L*, Fig. 5, this being shown in this way simply to illustrate the manner in which the projections of sand formed by the holes *K* in the block enter the depression in the cores formed by the core print *H* when placed in position upon the bed, closing this opening and assisting to form the gate.

It will be observed that the center core of the group contains the runner; this core can be rammed up in the same core box as the pattern, the runner pin being substituted in place of the pattern. When all cores are set, the cope is placed on and clamped down, the runner core arranged, and the mold awaits the metal.—American Machinist.

THE ELECTROLYTIC THEORY OF CORROSION.

THE Engineering News refers to the light thrown by the electrolytic theory of corrosion on the question why iron corrodes so much more easily, under common conditions, than copper, lead, or zinc. It makes this suggestion: "In Ostwald's table iron is shown to be close to the critical point of change in ionic action, while the other metals named are distant. This position of iron indicates that while there is a tendency for metallic ions to pass from the metal to the solution in which it may be immersed, the common physical and chemical irregularities are probably great enough to reverse in certain areas the normal tendency, causing more continuous electrolysis and rendering electrical equilibrium more difficult. In the case of the other metals, in samples that have resisted corrosion, it may safely be assumed, first that the physical and chemical heterogeneity is less marked than with iron. These metals being farther removed from the critical point of change in ionic action, the influence of such irregularities in the metal may easily be conceived as unable to reverse the normal tendency for the exchange of metallic ions between metal and solution. The potential difference between the metal and the solution is then always unidirectional, though varying slightly at different parts of the metal body. The light resultant currents and the very slight electrolysis would tend to equalize the potentials, establish electrical equilibrium, and limit further corrosion."

As to the practical value of the new explanation of rusting this comment is made: "From the older theories it was seen that air and moisture were to be kept away from the iron or steel, and protective coverings have been developed with the idea as fundamental. Paints that were thoroughly or permanently nonporous have not appeared and iron structures still rust in spite of the best of care. It would seem possible that the additional knowledge gained from the experiments carried on in developing the new theory could lead to the invention of some protective covering that would inhibit the electrolytic action. Possibly the agitation may develop a truly non-porous protection which is practical."

In the paper detailing experiments in support of the electrolytic theory, presented by Allerton S. Cushman at the Atlantic City meeting of the American Society for Testing Materials (SCIENTIFIC AMERICAN SUPPLEMENT Nos. 1652 and 1653) the efficacy of chromic acid and its salts as inhibitors of rust was emphasized. It was granted that laboratory tests are not conclusive; nevertheless, in the opinion of the writer, "chromic

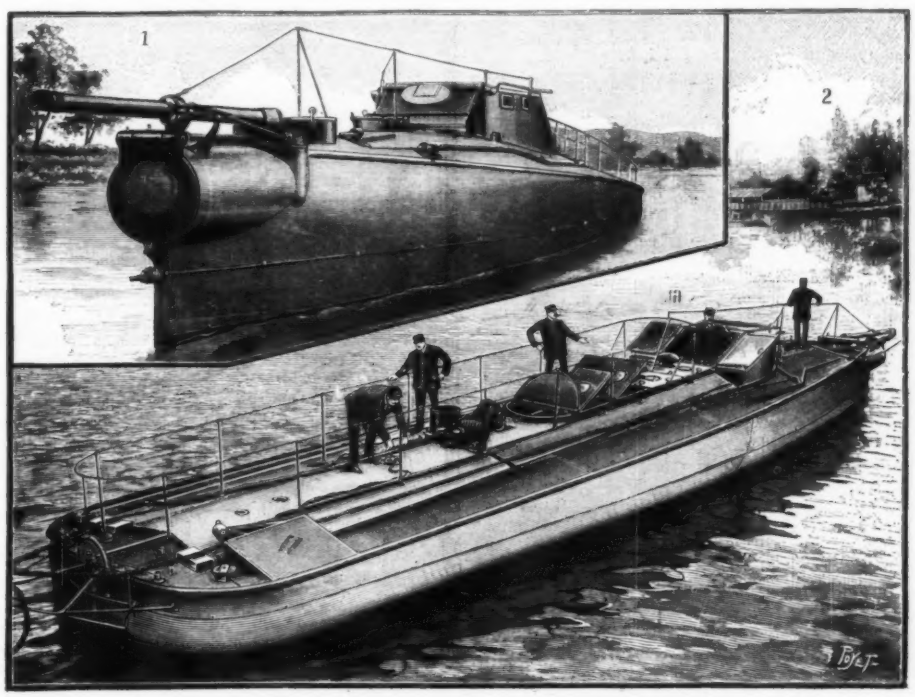
acid and its salts should under certain circumstances come into use to inhibit extremely rapid corrosion by electrolysis."

The only test of this character that has been reported on formally was made by the Committee of Tests of the Master Car and Locomotive Painters' Association. In its report of 1906 the committee referred as follows to the results with a small plate of steel exposed to the weather for twenty-eight months after having been treated with "a chromic acid rust neutralizing process." The chromic acid preparation was applied with a knife over the entire surface, half of which was then coated with a graphite and oil mixed paint. The committee says of the condition of the specimen: "It shows that all up-to-date attempts at chemically oxidizing a steel surface against future corrosion have been attended with failure, such as is indicated by this badly under corroded plate so treated, but you will also please note that the single coat of honest graphite paint is still a protective coating, notwithstanding the hard task of holding its ground against this most powerful acid, said to be soluble only in water, which, if true, would fully account for its apparent failure as a corrosive preventive."

A TORPEDO BOAT DRIVEN BY KEROSENE.

A NEW APPLICATION OF LIQUID FUEL.

A KEROSENE-DRIVEN torpedo boat has been constructed for the French navy according to designs furnished by M. Récopé, a retired naval engineer and now the vice-president of the yachting committee of the Automobile Club of France. The boat is about 56 feet long and has a hull of sheet steel 1-12 inch in thickness. It is equipped with two explosion motors which burn illuminating oil (kerosene), and together develop 150 (French) horse-power, at 900 revolutions per minute. The motors are of the Cazes marine type, and have four cylinders. The transmission and speed changing mechanism has been considerably simplified by the employment of a reversible screw propeller, of the Krebs type. The torpedo tube is placed at the bow. The torpedo weighs about 1,000 pounds and carries 220 pounds of explosive. Its initial velocity is 30 knots. The speed of the boat is 16 knots and its radius of action exceeds 100 nautical miles. With its hoods closed it is almost invisible at a little distance, while its small size admits of its being carried on the deck of a warship.—La Nature.



A TORPEDO BOAT DRIVEN BY KEROSENE.

NAVIGATING WITHOUT HORIZON.*

By CAPT. BRADLEY A. FISKE, U. S. Navy.

I HAVE had the idea for many years that ships could find the altitude of a heavenly body, when the horizon could not be seen, by taking the angle between that body and the water-line, or other part, of some ship under it, and at a known distance from the observer; the dip being found by computing the angle subtended at that distance by the difference in height between the observer's eye and the part of the target-ship angled on.

I have suggested this method to a great many officers at different times. They have all said that they could see no reason why it would not work, and that it ought to be tried.

But it was never tried by anyone, so far as I know, until the night of August 2, 1907, when it was tried by Lieutenant-Commander Yates Stirling, Jr., to whom I had suggested that he try it whenever he got an opportunity. Mr. Stirling was then navigator of the U. S. S. "Arkansas," and I the captain.

I will let Mr. Stirling tell of the incident in his own words. "On the night of August 2, 1907, the 'Arkansas,' in company with the other ships of the Practice Squadron, was standing on a course N. ¼ E. (magnetic), to make Seguin Island at the mouth of the Kennebec River. The ships were enshrouded in a dense fog, and had been steaming in this fog since leaving Block Island 16 hours before. About 10.30 P. M., the fog became less dense; and about 10.35 it cleared away sufficiently to make out distinctly the lights of the 'Florida' and 'Olympia.' Overhead the sky was cloudless and many stars were visible; but the horizon could not be seen.

"It had been many times suggested by Capt. Fiske, that he would like to see tested a method of taking a sight in a fog, using a ship or a boat as a base from which to measure the altitude. It occurred to me that this was a very favorable opportunity; and I decided to attempt to get the latitude by altitudes of the Polar Star.

"I detailed one midshipman with stadimeter to take the distances of the 'Florida' and 'Olympia' at the times of sights, and one to mark the times.

"The ship was steered so as to bring the stern lights of the 'Florida' and 'Olympia' directly under the star, successively.

"The altitudes were taken by me, Polaris being brought down very readily to the stern lights of the 'Florida' and 'Olympia,' just 500 and 1,000 yards away respectively, as measured by the stadimeter.

"The latitude found was 42 deg. 46 min. 9 sec. in the case of the 'Olympia' and 42 deg. 43 min. in the case of the 'Florida.'

"At 1:30 A. M. I got a sounding in 31 fathoms on Platt's Bank, which fixed our position within one mile. I worked back from this position, and found that the latitude at the time of the sight of Polaris was 42 deg. 45 min. 30 sec."

Naturally, I was delighted with Mr. Stirling's success; so in the forenoon of the next day, August 3, 1907, when the ship was at anchor in a dense fog off the mouth of Kennebec River, Maine, and I saw another opportunity to test the method, I directed Lieutenant H. C. Cocke and Midshipman J. C. Hunsaker to try to get observations near noon; and I sent out the dinghy sunward to be used instead of the horizon. Although the sun was shining brightly, the fog was so thick that the boat could be seen only a short distance; this distance was found to be 173 yards. Mr. Cocke's and Mr. Hunsaker's observations of altitude agreed within one minute. Mr. Cocke's altitude gave a latitude of 43 deg. 46 min., Mr. Hunsaker's 43 deg. 47 min. The position of the ship, as determined by observations on Seguin Island, after the fog lifted, showed the latitude to be 43 deg. 42 min. 15 sec. The mean of the two observations therefore was 4 min. 15 sec. in error. Inasmuch as the observers secured very good observations, the cause of this error lies probably in an incorrect measure of the distance; which, on account of the distance being so small, would make a great deal of difference in the dip.

Thinking that this might be the case, I directed Midshipman Hunsaker to get a longitude observation on the afternoon of August 5, 1907, while at anchor off Bath, Maine. I sent out a whale boat to sunward, and arranged carefully that the observer of the altitude on board, and the observer with stadimeter in the boat should take their observations simultaneously.

The tide was running strong, and it was hard to keep the whale boat at a constant distance; and as its distance was very small, only about 155 yards, the mean of the altitudes was not taken; but the observations were worked out singly. As a matter of fact, only four were worked out. The longitudes obtained were 69 deg. 53 min. W., 69 deg. 45 min. W., 69 deg. 51 min. W., and 69 deg. 47 min. W.

The mean of these observations is 69 deg. 49 min. W. The correct position as taken from the chart, whereon it was exactly located, was 69 deg. 48 min. 35 sec. W.

I respectfully submit this method to the consideration of mariners generally and naval officers particularly. At times it may prove of great value. Its most obvious use would seem to be in fleet work at night, when some heavenly body can be seen. All the commander-in-chief has to do, is to order some ship to take an observation. That ship will then steam to a point where some other ship of the fleet is under the moon, or some star or planet, and take the angle between it and some convenient line or point on the target ship. If desired, she can then take a similar observation on another heavenly body, bearing in such a direction from the first heavenly body as to give a good cut.

* Copyright, 1907, by Philip R. Alger, and reprinted from the Proceedings of the United States Naval Institute.

"BREATHING WELLS" IN FRANCE.

AT the recent Congress of Swiss Naturalists B. Brunhes and P. David presented an interesting communication on a "Breathing Well" at the summit of the Puy de Dôme and the annual alteration in the direction of the air current at its mouth.

About two years ago the authors, having begun to enlarge the entrance to a cave situated at the summit of the mountain (at a height of about 1,410 meters), made some physical investigations on the nature of the cave in question.

Reports on "breathing wells" have been published from time to time in Switzerland, it being stated that whenever the outside pressure begins dropping, the air will escape from the well, in order to re-enter as soon as the outside pressure increases. At the Congress of Radiology and Ionization held at Liège, Ed. Sarasin mentioned the fact that the ionization of the air at the mouth of these wells is far stronger when the air current is going toward the exterior than in the opposite case. Now this fact would be at variance with what is known about the intense ionization in the interior of caves and cellars.

Preliminary experiments made with the Elster and Geitel apparatus brought out the fact that the well at the summit of the Puy de Dôme belongs to a somewhat special type of breathing well. The ionization of the air in the neighborhood of its mouth is generally of the same order of magnitude in summer as the ionization of the atmospheric air in its immediate vicinity, while in winter it is far stronger. The direction of the air current shows an annual alteration in direction independent of the atmospheric pressure.

These facts were confirmed by installing a self-recording thermometer in the cave at 6 meters below its mouth, showing that no diurnal (daily) alteration occurs in winter, while a very marked diurnal variation takes places in summer. Throughout the months of January and February, 1907, strictly rectilinear records were found, showing the existence of a temperature of 4.1 deg. C., even when the outside temperature had dropped to —16 deg. The thick snow-layer covering the ground was melted around the circumference of the mouth, showing that a warm air-current was blowing from its interior. Very slight diurnal variations were observed from the 28th of March to the 1st of April, after which the curve till the 23d of April continued rectilinear. Slight breaks were thus alternating with rectilinear portions, until on the 4th of May a marked diurnal fluctuation was observed, the temperature rising to 7 deg. at about 10 o'clock in the morning, dropping on the same day

to 4.1 deg., thus showing that the air current in the course of the day had altered its direction, at a time when the temperature of the outside air was higher than that of the inside air. The prevalence of diurnal variations in the interior of the cave commences definitely on the 26th of June, beginning from which date the outside temperature is higher. Special experiments and comparisons with air pressure records show that this constancy or variability of the temperature in the cave is independent of the pressure of the outside air.

This "breathing well" thus has a draft comparable to that of a chimney, and no doubt communicates with the outside air through other deeper apertures. In order, however, that the air traversing a cave may assume a very constant temperature, as observed throughout the winter, the cave should be very spacious. The constant temperature referred to is somewhat higher than the annual average of the air temperature at the summit of the Puy de Dôme, which from 1879 to 1906 has been 3.9 deg. C. The inside temperature thus corresponds to an average annual temperature in an air layer situated somewhat below the summit.

NOTES ON TUNING IN WIRELESS TELEGRAPHY.*

A BRIEF ACCOUNT OF RECENT METHODS.

BY SIR OLIVER LODGE.

I SHALL assume that the principles of tuning are known; it is not to be supposed that the application of these principles requires the arc. Sufficient tuning for all practical purposes can be obtained by using the right kind of spark. It is possible to acquire too long a train of waves, in which case the latter half of the train will undo what the former half has begun, in analogy with beats. Thirty or forty swings can be easily got by a spark, and that is enough for practical requirements.

A non-tuned station puts all the energy into a single snap, so as to produce a single discontinuous pulse calculated to affect every kind of station within the range of its power. For a tuned station this sudden snappy spark is to be avoided. The ideal arrangement is a spark of a sufficient number of alternations of approximately equal strength, no one of which is sufficient to operate, but such that the accumulated influence of all of them is powerful. Instead, therefore, of the clear polished metal knobs in fresh or compressed air, which are suitable for a snappy spark, a tuned station may employ a series of points inclosed in ionized air, so as to maintain conduction as long as possible. The maintenance is also assisted by using an alternator with a curve of the right shape—not a sine curve, but a high-shouldered curve (see Fig. 1)—so as to keep up the stimulating potential for a sufficient time. The spark passes when the potential corresponds to the point *a*, and a number of oscillations of nearly equal intensity are made between *a* and *b*.

But attention to the spark alone is not sufficient; it is necessary to eliminate the influence of the earth. For the snappy or non-tuned emission, such as was employed by Mr. Marconi for great distances, it is convenient to use an elevated wire on the one hand, and the earth on the other; but for a tuned station this is not appropriate. A tuned station requires two capacity areas above the earth. These capacity areas are usually horizontal frames (see Fig. 2) of shapes devised by Dr. Alexander Muirhead, who has found that there is a best position for the lower aerial, such that the capacity is a minimum. If the lower aerial be too much raised, the radiating power is diminished; if it be lowered, the train of waves is shortened, until when it is allowed to touch the earth—still more if it is connected with the earth—there is hardly any train of waves at all, and the discharge is almost dead-beat.

There is a great advantage in the getting rid of earth contacts, inasmuch as variations of moisture and uncertainties of the soil do not enter in to confuse the problem and throw the tuning out. But even if the earth remained constant, it would be deleterious; it seems by its resistance to damp out the vibrations and shorten the train of waves, in so far as it is allowed to exert any influence.

To receive a message from a distant tuned station, the first thing is to tune up accurately the receiver. This can be done by a Duddell radio-micrometer, which measures the received energy satisfactorily, although it is very small. Tuning is altered until the reading on this micrometer rises to a high value, then the receiving apparatus is purposely made unsensitive, so that the coherer will only respond to this high value; in other words, to the top of the curve. The message can then be received from the desired station. If the receiving apparatus were left sensitive, it would be affected violently by the desired station, but it would pick up a number of disturbances from other stations. By working at the top of the curve, it feels the desired station alone.

Tuning at the Sending End.—In order to economize power, it is desirable to have every part tuned. The aerials connected through the secondary of a peculiarly-made Ruhmkorff coil constitute one oscillating system of a low frequency, to correspond with an ordinary commercial alternator which excites them. When the swing is worked up, they burst through the spark-gap, short-circuiting out the Ruhmkorff, and giving excessively rapid oscillations, which are the ones transmitted. These are picked up by the receiving station, and transferred at constant frequency into a closed condenser-circuit (see Fig. 3), which, when its swings reach a maximum, overflow into the coherer. This is called the "overflow method," and was described by me in 1889 and 1891.

Theoretical calculations show that the energy received, compared with the energy radiated, depends on the cube of the linear dimensions of emitter and receiver, if they are alike, and likewise on the cube of the distance between them. Measurements made with the radio-micrometer confirm this estimate ap-

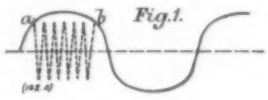


Fig. 1.

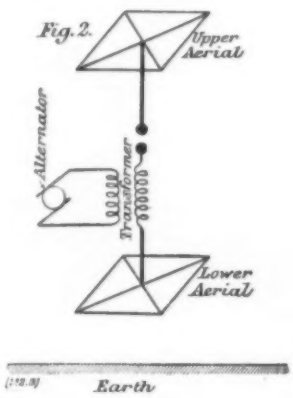


Fig. 2.

proximately, the value in one series of experiments being 10^{-9}. Although this is a small fraction, the accuracy of the tuning is such that messages are sent between Burma and the Andaman Islands—a distance or about 300 miles—with less than a horse-power. To get such a result, precautions must be taken to avoid damping out the oscillations, not only by elevation of the lower aerial above the earth, but by using appropriate condensers for these excessively high frequencies. To this end the wires used are finely subdivided in insulated strands, and consist of a great cable or bundle of thinly insulated No. 40 wires, and the various self-

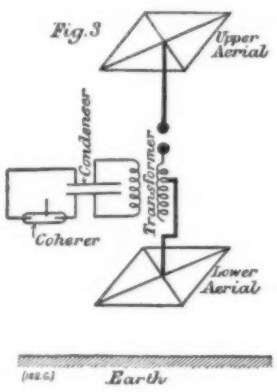


Fig. 3

inductions, and other arrangements for effecting tuning, are similarly wound. The tuning capacities are also arranged so as to be continuously adjustable without pegs or discontinuities, and every kind of broken or uncertain contact is scrupulously avoided.

* Abstract of paper read before the British Association at Leicester, August 5, 1907.

SOME PROPERTIES OF ELECTRONS.*

INVESTIGATIONS concerning the nature of the process of electric conduction in metals have led to the conclusion that in the metals are to be found molecules and atoms of the metallic element, positive ions and free electrons. The molecules and atoms are not free to migrate from one part of the metal to another, but have a limited freedom of movement about a mean position. The electrons are not constrained to any particular part of the metal, but are free to move from one part to another, such movement being accompanied by collisions and changes in the direction of movement, in a manner similar to that accompanying the movement of molecules in a gas, considered from the standpoint of the kinetic theory of gases. The positive ions have been supposed by some to change their positions, by others not. The number of free electrons per cubic centimeter of metal is very large, being of the order of a billion billions. The mean free path of an electron scarcely exceeds one-millionth of a centimeter in any case. The number per cubic centimeter and the length of free path is different with different metals. In an ordinary metal at a uniform absolute temperature of T degrees all the particles of the metal are in motion, collisions are constantly occurring and the directions of the motion are such as result from chance. According to the doctrine of equipartition of energy the mean kinetic energies of the molecules of the atoms, of the positive ions and of the electrons are equal to each other and dependent upon the absolute temperature. Inasmuch as the masses of the electrons are much smaller than those of the other particles, the velocities of the electrons must be much greater.

Solid dielectrics probably contain some free electrons, although the number per unit volume is small compared with that in metals. To free electrons is due the conductivity of solid insulators that remain after surface leakage has been prevented. Free atomic ions are probably absent, since conditions through their mediation would result in a transport of matter with accompanying differences in the chemical and physical character of the surface layers of the dielectric when kept between conductors having a maintained difference of potential.

At all temperatures above absolute zero all bodies radiate energy. If the nature of the body be not changed by this radiation, that is, if it continues to radiate in the same manner, as long as its temperature is maintained constant by the addition of heat, the process is termed pure temperature radiation. If, on the other hand, the body changes because of the radiation and does not continue indefinitely to yield the same radiation, although its temperature is kept constant, the process is termed luminescence. The cause of some of the radiation in the latter case does not lie in the temperature of the system, but in some other source of energy. According as the extra supplied energy accompanies either chemical transformations, exposure to light, or the passage of electric currents, the processes are respectively termed chemico, photo, and electro-luminescence. The total radiation from a body of this class is made up of two parts—that due to its temperature and that due to the extra energy. If the intensity of radiation of a body within any region of wave-lengths is greater than that of a black body at the same temperature, luminescence must be present. This is frequently taken as a criterion for the detection of luminescence. The frequencies of luminescent radiations are more or less restricted, being often evidenced by bright-line spectral distributions. The electrons which yield these radiations are supposed to vibrate harmonically under conditions that are not yet understood. That their movements are not governed simply by chance seems to follow from the character of the spectra. Although change in the character of the material as a consequence of its yielding luminescent radiation may not be capable of detection by chemical analysis, yet the atomic and molecular systems are nevertheless doubtless undergoing constant changes, due to the loss or gain of electrons. The entrance of an electron into a system, or its ejection, must, without doubt, occasion complex harmonic disturbances of many or all the electrons in the system.

If luminescent radiation be confined chiefly to wave-lengths of the visible spectrum the luminous efficiency of the body becomes high. Herein rests the economic significance of the efforts being made to advance the art of lighting by means of vacuum tube and flaming arc lamps.

A very interesting example of luminescent radiation is that which is yielded by photogenic bacteria, which are frequently found in sea-water and upon meats and fish that have been directly or indirectly infected by

* From Presidential Address at the Niagara Falls Convention of the American Institute of Electrical Engineers.

sea-water. They are the sources of light known as the phosphorescence of the sea. Some cases of phosphorescence in animals and in plants are explained as an infection with them. Gorham has shown that the light which they give is the result of chemical transformations accompanying metabolism inside the cells.

In conclusion; although much is known concerning the size and mass of the electron, its electric and magnetic effects when in motion, and its radiation effects during acceleration, little more is known concerning its structure than that it is the intrinsic strain-form alone that constitutes the electron; and it is a fundamental postulate that the form can move from one portion to another of the stagnant ether somewhat after the manner that a knot can slip along a cord.

ETCHING SUGGESTIONS.

SOME MODERN PROCESSES.

IN etching work two operations are necessary:

1. The production of the protective coating, known as the etching or covering ground, in accordance with the design to be produced.

2. The application of the etching fluid, the caustic liquid.

The etching ground, if it is to answer its purpose, must primarily fulfill two conditions. It must resist the acids and attach itself so firmly to the metal, that it will not be detached by the bubbles of gas formed during etching. These requirements are best met by certain gums or resins like asphalt, mastic, resin, as well as beeswax alone and in combination with the resins mentioned. In more recent times special kinds of covering substances have been used, for instance, chrome-gelatine, chrome-albumine, and printers' ink, which furnish but little protection and consequently serve only for etchings of moderate depth and require a certain reinforcement.

In the oldest process for the production of etchings on metal the thoroughly cleansed metal surface, on which the etching is to be made, is coated with a melted mixture of resins and wax and the lines of the drawing scratched so deeply in this covering that the clean metal is exposed. A plate scratched in this manner is then surrounded with an edge of soft wax and in the dish thus formed, the bottom of which is the plate to be etched, the etching fluid is poured and allowed to remain there long enough to insure the corroding of the lines in the metal to the desired depth.

The designs on such plates can be printed just as well as engraved plates, in the copper-plate printing press. For hundreds of years a large number of artists have employed this process as a substitute for copper-plate engraving and produced prints from the erased plates on copper-plate presses.

One of the earliest was probably Albrecht Dürer. His plates made in 1515-1516 were etched on steel plates as the rust spots, to be found in the impressions, prove.

Not only in the studios of the artists, however, but in the workshops of the artsmiths and armorers, the art of etching was practised. Possibly it was known in these homes of industrial art before it found employment by artists for the multiplication of their productions. It was known in the fifteenth century that iron was attacked by etching fluids, and that by this means designs on arms, etc., could be produced. One section in the "Schedula" indicates that even in the twelfth century the etching of iron was practised.

In modern times this etching or incising process has undergone development and transformation by the employment in place of the ground made from resin mixtures of a layer of metal (usually gold is employed) which is capable of offering adequate resistance to the etching fluid.

When in 1841 De la Rive discovered the gilding of copper by the wet process, he speedily demonstrated how this process could be utilized in etching, by first gilding the copper surface to be etched and then carrying out the scratched design on the gold ground. The erasures which could be made either with the needle or with a diamond, proved much more delicate on the gold ground than on the ordinary background; any necessary corrections may also be more easily made.

In artistic work it is usually necessary that the design be raised or elevated. By the process above described this cannot be effected.

For etching plates in relief the protective ground consists of a paste, soluble in water and lightly applied. The scratching is done with pointed quills, not split, whereby the metal plate is left bare on the places that are intended to remain in relief. To protect these spots from the action of the etching fluid they are coated with a solution of Syrian asphalt. After the asphalt has dried the plate is laid in cold water, whereby the white covering ground is dissolved, whereas the asphalt coating is unaffected and the parts it covers are protected against too deep an etching.

More often, for the purpose of producing artistic etchings, in which it is desirable to obtain the designs in relief, the work is done by painting protecting ground on the metal. For this purpose the protective coating ordinarily used in "erasing" work is dissolved in oil of turpentine and this acid-resistant or paint applied only to the parts of the plate that are intended to remain in relief. After the drawing is dry the plate is surrounded with a wax rim and etched as already described.

The painted patterns are either previously drawn on or transferred to the metal and after the covering ground is dry any defective spots can be readily corrected with the needle and the shading and finer details added.

Although primarily etching was developed and employed for the production of printable plates for book printing, copper-plate printing, and lithography, it was also of the greatest service to the metal industries, particularly where various objects were to be ornamented with the same design.

Of special importance is the transferring process, which may be either a chemical or mechanical process.

From an engraved or incised copper or zinc plate impressions in thick, pasty color on thin tissue paper are pulled and pressed down on the surface to be etched. After the paper has been wetted it is pulled off the plate, the device remains on the metal and forms sufficient cover to protect it against the attack of the etching fluid.

In lithography and on the printing press such impressions could be made, but they are not sufficiently resistant to withstand deep etching, for which reason, after the first etching, a reinforcement of the transfer is effected by sprinkling powdered resin, which adheres to the ink, and heating the plate until it melts.

The photo-etching process is simple to work. Gum Arabic and albumine are soluble in cold water. If to such a solution we add a solution of bichromate of potash, coat a plate with the mixture and expose it, after drying, the exposed parts lose their solubility in cold water, but are soluble in weak acids. The exposed parts readily take up printers' ink and retain it. Chrome gum may, therefore, be used in two ways. (a) After the plate coated with chrome gum has been exposed to light under a negative, it is completely coated with printers' ink. If the plate is thereupon immersed in cold water, the unilluminated (non-exposed) parts are dissolved, taking the ink with which they are coated, with them. The illuminated portions tenaciously retain the ink. After etching the design is obtained in relief. (b) If the exposed plate is transferred directly to a dish filled with cold water the unilluminated places will be dissolved. After drying, the entire plate is coated with a very fat printing ink, or with shellac solution, and placed in a dish containing dilute hydrochloric acid. The illuminated places are also dissolved here and continued etching produces an incised drawing.

With chrome-gelatine we proceed in almost the same manner. Gelatine alone swells in cold water and dissolves in warm water. Illuminated (exposed to light) chrome gelatine can no longer be dissolved in cold water but only in mineral acids. For light etchings it can, therefore, be used in the same manner as chrome-albumine and chrome-gum.

More convenient, however, is the transfer process with chrome gelatine paper, as discovered by Prof. Husnik in 1873. If paper is coated with gelatine and after drying made sensitive to light in a chrome-salts bath, it retains the faculty, after drying, of swelling up in cold water. If, however, we expose the sensitized paper to the light, we shall find that only the unilluminated parts will swell in cold water, so that we obtain a relief in which the relief parts reproduce the lights, the depressed places reproduce the shadows—in other words, the original drawing.

Then this gelatine relief possesses the remarkable property of only taking the printing ink on the illuminated places. If we coat the exposed paper, before softening it, with an ink containing wax and allow it to soak for a time in cold water we can easily, with a moist sponge, wipe the ink from the swelled places, so that we have a positive picture in black that can be transferred to metal plates.

The photo-chemical etching processes play an important part nowadays in the production of printing plates.—Translated from the German of H. Schuberth in "Das Aetzen der Metalle."

SYNTHETIC CAMPHOR.

LITTLE more than twelve months ago no precise information could be obtained with regard to the production of synthetic camphor. Within the past few weeks, however, proof has been forthcoming that artificial camphor is now a reality, and we understand that both British and Continental firms are engaged in its production. The making of synthetic camphor has been a problem which has engaged the attention of chemists all over the world for many years, and its final solution is by no means the least achievement of modern science. The firms referred to preserve the strictest secrecy with regard to the processes employed by them, and some of tnem have not actually placed the product on the open market. All the artificial camphor turned out by certain makers has up to the present been utilized in their own works as a substitute for the natural product, but one London firm, at least, is in a position to quote prices.

The ketone, camphor, the secondary alcohol, borneol, and the hydrocarbons, camphene and pinene, are intimately related, and most of the synthesis of camphor consists in the oxidation of synthetic borneol. There are at least four methods for producing synthetic camphor, and in all turpentine oil—or, strictly speaking, pinene, which forms 70 per cent of the bulk of turpentine oil—is the starting point. The first method, an American patented process, consists in the action of dry oxalic acid on turpentine oil. Camphor, however, is not formed in this process, but about 30 per cent of esters, which, on hydrolysis, yield borneols, and these can be directly oxidized to camphor. But the product in this case is small, and the method has been abandoned as impracticable, as also has the modification embodying the use of salicylic acid instead of oxalic acid. A second method makes use of the interaction of pinene hydrochloride with acetates to give isoborneol acetate, which is then hydrolyzed with alkali, and the resulting isoborneol oxidized to camphor. A third method, a German patent, is founded on the production of the synthetic camphor from pinene hydrochloride by Grignard's reaction. In this there is first produced a complex compound of pinene hydrochloride, magnesium, and ether, which is oxidized on exposure to the air, treatment with diluted acids giving rise to magnesium chloride and borneol, which latter is oxidized to camphor. Fourth, when pinene hydrochloride is treated with reagents capable of removing the elements of hydrogen chloride, such as secondary bases, gaseous ammonia, or phenolates, camphene is formed. When this is treated with a mixture of sulphuric and acetic acids, isoborneol acetate results; this is saponified, the solid isoborneol collected, purified by crystallization from benzene or petroleum ether, and oxidized to camphor by using potassium permanganate, chlorine, ozone, or hypochlorites, etc. Isoborneol, however, can be directly oxidized to camphor. The obstacles in the way at present are of an engineering rather than of a chemical nature, and the manufacture may for a time be further impeded by the present price of the starting material, i. e., turpentine oil, for the price of this has doubled in six years. It is only a question of time, therefore, before synthetic camphor may paralyze the industry in the natural product, if it does not annihilate it altogether, so far as its use on an industrial scale is concerned.

The synthetic is identical with the natural product in chemical structure and in chemical properties, but not in the matter of optical activity, the natural product being dextro, while the manufactured article is lævorotatory. But this point does not in the least influence the use of synthetic camphor in the manufacture of celluloid, where 90 per cent of the world's supply of camphor is at present consumed. With regard to its use in pharmacy it is doubtful if that will be great, for some time, at all events. Judging from the samples we have already examined, we can readily believe that it may replace the natural product, as soon as the price will allow, but it may be considered that the odor is less fragrant than that of natural camphor. The odor certainly is camphoraceous, but a spirit or ointment made from the new product might appear pharmaceutically inferior. Apart from the odor, the samples which we have examined have been in the form of "flowers," indistinguishable by touch or appearance from natural camphor, and having the peculiar property, like the latter, of clinging tenaciously to glass surfaces. The synthetic camphor burns with the familiar, intensely smoky flame, and vaporizes rapidly when the flame is blown out. We have not yet seen the compressed form, but understand that this is a more presentable article than the natural, being very translucent. The consumption of camphor in medicine, however, is comparatively slight, and has not a predominant influence on the market.—The Pharmaceutical Journal.

ARMY DIRIGIBLE AIRSHIPS.

SPECIFICATIONS PUBLISHED BY THE SIGNAL CORPS OF THE U. S. ARMY FOR THEIR CONSTRUCTION.

PRELIMINARY.—This specification covers the construction of a dirigible balloon, to consist of a gas bag supporting a suitable framework on which will be mounted the necessary propelling machinery.

Inspection.—The Chief Signal Officer of the Army will reserve the right to inspect any and all processes of manufacture, and unsatisfactory material will be marked for rejection by the inspectors before assembling.

Acceptance.—The dirigible balloon will be accepted only after a trial flight, during which it will comply with all requirements of this specification. The government reserves the right to reject any and all proposals.

GENERAL REQUIREMENTS.

The general dimensions of the dirigible balloon will be determined by the manufacturer, subject to the following conditions:

1. The gas bag shall be designed for inflation with hydrogen, the material for which will be furnished by the Signal Corps. This material is silk, covered with an aluminium preparation, and requires no varnish. It weighs 5.842 ounces per square yard and has a minimum breaking strength of 62½ pounds per inch width. This material for the gas bag will be furnished by the government, and samples may be seen in the office of the Chief Signal Officer of the Army, Washington. Bidders must state in their proposal the number of square yards of the material they will require. The dimensions and shape of the gas bag will be as desired by the manufacturer, except that the length must not exceed 120 feet.

2. Inside the gas bag there will be either one or two ballonets having a total capacity of at least one-sixth the total volume of the gas bag. Leading to the ballonets there will be tubes of proper size connected to a suitable centrifugal blower for maintaining a constant air pressure in the ballonets. The fabric for the ballonets will be supplied by the government. It weighs 2.857 ounces per square yard, and has a minimum tensile strength of 48½ pounds per inch width. Bidders must state in their proposal the number of square yards of this fabric they will require.

3. Valves.—In the lower part of the ballonet and gas bag or on the ballonet air tubes near the gas bag, there will be an adjustable automatic valve designed to release air from the ballonet to the outside atmosphere. On the under side of the gas bag there will be a second adjustable automatic valve of suitable size, so designed as to release hydrogen from the interior of the gas bag to the outside atmosphere. This valve will also be arranged so that it may be opened at will by the pilot.

4. In the upper portion of the gas bag there will be provided a ripping strip covering an opening five inches wide by six feet long, with a red rip cord attached in the usual manner and brought down within reach of the pilot through a suitable gas-tight rubber plug inserted in a wooden ring socket.

5. The suspension system and frame must be designed to have a factor of safety of at least three, taking into account wind strains as well as the weight suspended.

6. A type of frame which can be quickly and easily assembled and taken apart will be considered an advantage.

7. The balloon must be designed to carry two persons having a combined weight of 350 pounds, also at least 100 pounds of ballast, which may be used to compensate for increased weight of balloon when operating in rain.

8. The dirigible balloon should be designed to have a speed of twenty miles per hour in still air, but bidders must submit quotations in their proposals for cost depending upon the speed attained during the trial flight, according to the following schedule:

	Per cent.
20 miles per hour	100
19 miles per hour	85
18 miles per hour	70
17 miles per hour	55
16 miles per hour	40
Less than 16 miles per hour rejected.	
21 miles per hour	115
22 miles per hour	130
23 miles per hour	145
24 miles per hour	160

9. The speed accomplished during the trial flight will be determined by taking an average of the time over a measured course of between two and five miles, against and with the wind. The time will be taken by a flying start, passing the starting point at full speed at both ends of the course. This test subject to such additional details as the Chief Signal Officer of the Army may prescribe at the time.

10. Provision must be made to carry sufficient fuel for continuous operation of the engine for at least two hours. This will be determined by a trial endurance flight of two hours, during which time the airship will travel continuously at an average speed of at least 70 per cent of that which the airship accomplishes during the trial flight for speed, stated in paragraph 9 of this specification. The engine must have suitable cooling arrangements, so that excessive heating will not occur.

11. Three trials will be allowed for speed as provided for in paragraph 9, and three trials for endurance, as provided for in paragraph 10, and both tests must be completed within a period of thirty days from the date of delivery, the expense of the tests to be borne by the manufacturer.

12. The scheme for ascending and descending and maintaining equilibrium must be regulated by shifting weights, movable planes, using two ballonets, or other approved method. Balancing by the aeronaut changing his position will not be accepted.

13. This dirigible balloon will be provided with a rudder of suitable size, a manometer for indicating the pressure within the gas bag, and all other fittings and appurtenances which will be required for successful and continuous flights, according to this specification.

14. Bidders will be required to furnish with their proposal a certified check amounting to fifteen per cent of the price stated for the twenty-mile speed. Upon making the award for this airship these certified checks will be returned to bidders, and the successful bidder will be required to furnish a bond, according to army regulations, of the amount equal to the price stated for twenty-mile speed.

15. Bidders must submit with their proposals drawings to scale showing the general dimensions and shape of the dirigible balloon which they propose to build under this specification; a description of the engine which will be used for the motive power; the material of which the frame will be constructed; sizes of valves, etc. Plans received will not be shown to other bidders.

16. Bidders must furnish evidence that the government of the United States has the lawful right to use all patented devices or appurtenances which may be part of the dirigible balloon, and that the manufacturers of the dirigible balloon are authorized to convey the same to the government.

17. The price quoted in proposals must be understood to include the instruction of two men in the handling and operation of this airship. No extra charge for this service will be allowed.

JAMES ALLEN, Brigadier-General,
Chief Signal Officer of the Army.

Signal Office, Washington, D. C., December 14, 1907.

The completed balloon with equipment is to be delivered at Fort Myer, Va. Proposals will be received at Washington, D. C., up to January 15, 1908.

Parseval. "Nulli Secundus." Gross.

De la Vaulx. Zeppelin. "Ville de Paris."

THIS PICTURE, TAKEN FROM OUR PARISIAN CONTEMPORARY "LA VIE AU GRAND AIR," HOWEVER FANCIFUL IT MAY BE, GIVES A GOOD GL OF THE

DEGRAS.

Degras is a leather grease, very much in demand among leather dressers, which is obtained in part as a residual product in the tanning of chamois leather, and in part, because the quantity obtained from this source is inadequate, by artificial means. The manufacture of soft leather consists in the removal of the hair and fleshy matter from the skin, which is then "milled" with oil and occasionally hung in the open air or piled up in a warm room. The oxidation of the oil is thereby caused, and it acquires the property of combining with the animal fibers, giving them their leather-like character. Such of the oxidized fat as is not combined completely with the fibers, must be removed. This is effected, as far as possible, by mechanical means, by wringing and pressing, and the substance thereby expressed constitutes the choice quality of degras. Such as remains is removed by washing the skins in warm potash solution, by which means the fat is saponified and forms, with the lye, a white emulsion. If this is to be used as degras, it must first be decomposed, with the aid of sulphuric acid, and the fat separated by this means, freed from acid by washing. This yields the inferior grade of genuine degras. In order to produce this substance primarily, the process of chamois dressing is repeated with poor skins, until they are reduced to fragments, for the oleic acid extracts substances from the leather itself and makes it rotten. To what extent the production is aided by other means, by additions, etc., is not known. The article obtained from different sources varies greatly in quality. To introduce it into leather it must be mixed with water, with which it forms an emulsion. A few recipes for artificial degras are appended:

Degras from Refuse Fats.—Fat, which owing to its impurity cannot be used for other purposes, can be used in the preparation of degras. For this purpose, the fat is heated in a kettle to 248 deg. to 266 deg. F. for half an hour, keeping it constantly stirred, a very disagreeable odor being developed. Then stir into it 2 to 5 per cent of a one-half per cent soda solution.

Degras (artificial) from Train Oil.—A 10 to 20 per cent solution of potash is brought to a boil in a large kettle and into this vessel train oil is allowed to run slowly from a receptacle placed above it, the mixture being uninterruptedly stirred. The quantity of train oil to be used can only be determined by a knowledge of the different kinds of the oil. When all the oil has been added, the stirring apparatus should be kept going for quite a while longer, heating the mass constantly and from time to time taking samples. When the sample, poured into a tall glass and allowed to stand for some time, appears as a homogeneous, milky fluid, which, even at rest, does not manifest a tendency to separate into two layers, but only becomes thicker on cooling, the operation may be regarded as completed.

Artificial degras is obtained by the oxidation of animal oils, like cod liver oil, whale oil, and fish oil. (1) Allow the oil to pass through sieves, covered with finely divided lead, or with zinc powder coated with lead. The oil may contain 0.5 per cent of borate of manganese, it may be of the ordinary heat or may be heated to about 122 deg. to 140 deg. F. The air passing through the sieves may be either warm or cold. It is necessary to pass the oil through the sieves several times, in order to obtain the proper oxidation. (2) Oil which contains 0.5 per cent of borate of manganese is placed in a completely closed kettle, equipped with a stirring apparatus, the oil heated by means of a steam pipe to 176 deg. to 194 deg. F. and then air forced through at a pressure of 5 atmospheres. This process is said to be the best. (3) Atomizers or centrifugals may also be used. In these cases the oil as well as the air must be considerably heated.

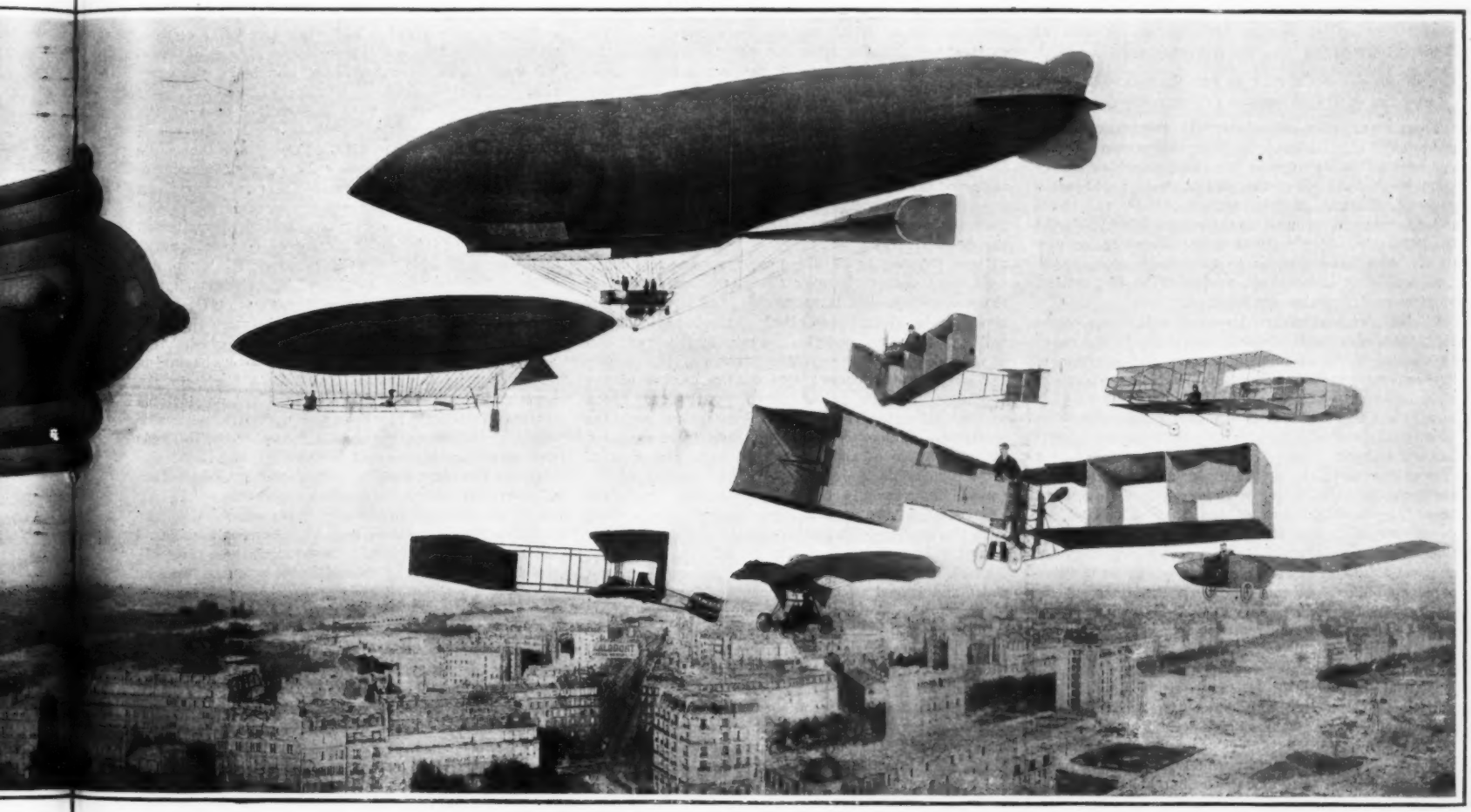
Mineral Degras.—One hundred parts of heavy mineral oil, 2 parts of palminate of magnesia, 4 parts of palminate of calcium melted together with 5 to 10 per cent of "moellon."

"Moellon" is oxidized oil of animal origin (train oil) chiefly used in the preparation of artificial degras. Moellon is prepared by forcing a current of air for some time through the oil heated to from 158 deg. to 176 deg. F. A previous addition of 0.5 per cent of manganese borate is usually made.

Degras, from Olein.—Produced in the same manner as that from train oil. Commence by allowing the olein to flow into the boiling caustic soda lye. When the fluid becomes milky, add potash solution and proceed to completion. If the sample is still too thin, add to the hot substance in the kettle a suitable quantity of olein soap (the soap to be cut into fine shavings and stirred in until the mass is homogeneous).

Black Degras.—To degras produced in the ordinary manner and stirred while still hot into tanning liquid or tan extract, a small quantity of green vitriol dissolved in water is added and then stirred for a short time. The entire mass is speedily colored deep black.—Chemisch-Technisches Lexikon (Bersch).

"La Patrie."



Santos Dumont No. 5. Farman. Vlua. Santos Dumont. Santos Dumont. Bleriot.

OF THE PRESENT STATE OF ARTIFICIAL FLIGHT. ALL THE CRAFT HERE SHOWN HAVE BEEN DESCRIBED AT LENGTH IN THESE PAGES.

AMERICAN CARS NEEDED IN INDIA.

Consul-General William H. Michael, in the following report from Calcutta, shows the desirability of the American railway train system in India:

"In consequence of recent murders, robberies and other outrages on trains in India, the Eastern Bengal State Railway has ordered electric alarm bells to be installed in the cars of their line, so that passengers may communicate with the guards on the train. It would appear that the only effectual and practical remedy is the substitution of cars built on the American plan, with open ends and vestibule connection for the side door arrangements used in India. The English passenger cars, or carriages, as they are called, which open at the side, are not suitable for India."

THE UTILIZATION OF SELENIUM.

Selenium, one of the rare and little-known elements, is closely related in many ways to tellurium and sulphur, with both of which it often occurs in nature. Recently it has obtained some prominence from its use in various forms of electrical apparatus, where advantage is taken of its peculiar property of being almost a non-conductor of electricity in the dark, while under the influence of light its conductivity immediately becomes greatly increased. This characteristic has led to its use in instruments designed for lighting and extinguishing gas buoys automatically; for guiding and exploding torpedoes by a ray of light, for telephoning along a ray of light; for transmitting sounds and photographs or other pictures to a distance by means of a telephone or telegraph wire; and for measuring the quantity of Roentgen rays in therapeutic applications. A general or practical use of any of these instruments would result in an increased demand for selenium.

At present the metal is variously quoted at from $13.33 per kilogramme (2.2046 pounds) to $2 per ounce, as there is no steady market and the prices vary with different dealers.

No selenium is known to be produced commercially in this country, but during 1906 one copper refinery made some in an experimental way, and it is possible that it was produced at other refineries also. At this refinery the selenium was obtained from the anode slimes or mud, where it is left with the gold, silver, and other residues in the electrolytic refining of the copper.

Minerals containing selenium are of rare occurrence in the United States, but a demand for the metal could probably be supplied by utilizing the small quantities found in the copper-refinery slimes.

A note on selenium, prepared by Frank L. Hess, geologist, is published in an advance chapter from "Mineral Resources of the United States, Calendar Year 1906," where the production of antimony, arsenic, and bismuth in 1906 is also reported.

THE GEOLOGY OF THE KLONDIKE.

GOLD PLACER GRAVELS OF THE KLONDIKE-YUKON DISTRICT OF NORTHWEST CANADA, YUKON RIVER, AND ALASKA ADJACENT FORTY MILE DISTRICT.

BY DR. WILLIS EUGENE EVERETTE.

DR. EVERETTE, of Tacoma, Wash., a mining geologist, gives the following account of this remarkable country, based on his personal observation and examination:

The following described geological investigation of the rocks of the Yukon River, near to and about at the boundary line of the Northwestern Territory of the Canadian Yukon, and the American Territory of Alaska, was made by me during the summer of 1884-1885, and from 1898 to 1907, while engaged in making a topographical and geological reconnaissance (together with an ethnologic study of the various Indian tribes) of the valley of the entire Yukon River, from its headwaters in the Coast Range to its delta at Norton Sound in the Behring Sea. The report as to the "deposition of gold in placer gravels" (not altogether torrential lixiviation) is also based upon actual investigation; and the report of dredger operations on the Klondike-Yukon gravels is collected up to date of October 10, 1907.

THE GEOLOGICAL FORMATION OF THE KLONDIKE-YUKON IN THE DAWSON MINING DISTRICT OF NORTHWEST CANADA.

From many years of actual field observations as a mining geologist, I have come to the conclusion that our practical knowledge of the methods which nature employs to form ore veins, and to form gold-bearing deposits of sands, gravels, detrital schists, and slates is inadequate to account for their deposition in all the conditions in which we find them; therefore, no new theory of gold deposition in gravel deposits can be accepted, until it has been proven to be of practical application for mining purposes.

Students of geology are, however, well aware of the fact, that when molten silicite, as silica in the shape of quartz, is forced into the cracks and crevices of broken rock masses, by the tremendous pressure of volcanic or of seismic disturbances, the fractures thus formed are filled with reticulating and irregular veins of such silica or silicite, to which the name of "quartz lodes" has been given.

It might therefore be presumed that the quartz of auriferous or gold-bearing veins of rock, in place, must be of igneous origin, and *not* the result of the gradual deposition of quartz, from an aqueous siliceous solution. But is this true? Is it not possible that hot aqueous solutions of alkaline silicates may have interpenetrated the fractures and cleavage lines of the broken rocks, and therein deposited siliceous forms of new rocks, which would radiate in every direction? I have recently found definite and tangible forms of such aqueous deposition in the gold ores of the Nevada deserts.

Without going into any detail to account for the absence of immense beds of clay (which should result from and in the decomposed felspars to form the necessary alkali of these aqueous alkaline silicates) or to account for the small amount or hyaline and opaline quartz found imbedded in the detrital schists (as should be necessary when quartz is precipitated from an aqueous solution), I will only refer to certain facts which have come to me through actual practical observations of the mining operations in the Yukon River valley and its tributaries, from my first reconnaissance in 1884, and thence nearly continuously up to and including 1907.

Geologically considered, the Klondike mining section of the Yukon Territory of Northwestern Canada was, in comparatively recent time, marinely submerged. The continental ice sheet, or the great glacier which once covered this northland from the mouth of the Pelly River to the headwaters of the present lake system of the Yukon River, did not cover the present topography of the Klondike region. No evidence of a vast and general rock glaciation can be found in the Klondike country; and rarely is there found any evidence of local glaciation, except in a few and isolated conditions. Vast shearing, bending, and twisting of the rocks of the ocean beds most undoubtedly took place, changing the basal rock into a schistosic and serpentine condition, ere emergence of these ocean floors began to rise above the surface of the ocean waters.

The absence of any soluble borates, nitrates, and chlorides of the alkalies in this Klondike region demonstrates that this emergence was of sudden seismic origin, and not from a slowly-dying volcanic origin. In general topography, this emergence was quite flat, or in a plane-like condition, and no doubt formed low, marshy lands, which rapidly changed into a lacustrine or lake-like country. Bogs, marshes, and lowlands were then covered with a rank growth of semi-tropical vegetation—for this sudden elevation of the ocean floor, together with the change from a sub-arctic to a semi-tropical climate, may have been attended by an orbital eccentricity, which, undoubtedly, would have caused a change in the Klondike vegetation from sub-arctic to semi-tropical conditions.

The partially fossil flora and fauna found imbedded in the detrital matter under the muck or peat bogs of the Klondike region show most conclusively that at the time of the formation of this "muck" the climate and temperature in the Klondike region must have been similar to what is now found in the "everglades" of Florida. A long period of quiescence then took place, and lake system flowing into lake system was formed. Thence came again sudden seismic or earthquake action, and terrace after terrace of ancient lake beaches and sinuous lake shores were formed, as we now find them. With the sudden emergence of the central peak in the Klondike district (that is, the Dominion Dome, with its attendant peaks and ridges), this Klondike lake system was shattered and violently broken, so that the great terraces or barriers at the mouths of the Klondike and the Indian rivers gave way, and the escaping lake waters were drained into the present broken lake-system, which is now the valley of the Yukon River. The entire topography of the Klondike country was thus changed from a flat-terraced lacustrine or lake-like marshy country into the present region of canyons, gorges, domes, and valleys, crossing in all directions from one another.

At the mouth of Hunker Creek, the flat bottom of the ancient lake bed is yet visible, and it extends for several miles along the left limit of the Klondike River valley. The same condition prevails at the lower end of the valley of the Forty Mile River.

When this tremendous and sudden change of the lake-like topography of the Klondike region took place, another climatic change was taking effect over the entire area of this northland, and a glaciated condition of the surface of the lakes was then in process of formation. The enormous force and energy of the seismic disturbance, acting on the escaping, overturned and agitated lake waters in tumultuous mass, along with the broken fields and fragments of thick lake ice, caused vast quantities of broken schists, serpentine, diabase, and silicious rocks; together with blocks, slabs, and jagged angular fragments of hard and clear blue-white ice, with muck, gravel, and sands of an earlier date, to form as detrital matter, and be deposited wherever the powerful current then carried them. The specific gravity of the muck (or fine vegetable mold), being so very much less than that of the rocks, caused this flocculent muck and marshy mud to remain suspended in the agitated waters, so that it did not precipitate until all the detrital rocks and gravels along with huge slabs and thick masses of hard ice had been deposited. Again, a long period of quiescence took place; and on the shores and bogs of the newly-formed creeks, and in the marshy lake-like canyon valleys, a new formation of vegetation began; and the local gravel deposits, peat bogs, and muck beds, as we now find them, were thus brought into existence.

No change has since taken place; but the Klondike region is still, however, slowly rising; and at the present rate of upward movement, in the course of a few hundred years there must undoubtedly come again a time when again a lacustrine or lake-like condition of the Klondike country will take place.

THE GEOLOGICAL STRUCTURE OF THE ROCKS OF THE KLONDIKE-YUKON DISTRICT.

The rocks and strata of the main section of the country that radiates from the Dominion Dome (altitude 4,250 feet, Dawson City is 1,210 feet), that is, from Indian River to the Yukon River, and from the mouth of Quartz Creek to the divide beyond Gold Bottom Creek, are a mixture of various forms of quartz porphyrite, gneissoid porphyrite, and some true porphyrite. These rocks are interspersed with cross-section dikes and veins of laminated sericite-mica schist, in all varieties of metamorphic, graphitic, indurated, friable, and silicified conditions, together with porphyritic trachyte, andesite, and rhyolite, with a small amount of pegmatic porphyrite.

Scattered throughout this mass of rocks are small lodes, reticulating veinlets, radiating plexuses, and irregular masses of both primary and secondary silicite (or quartz) in the shape of both igneous-formed quartz and aqueous-formed quartz, which were, no doubt, the original vein source of that part of the placer gold which was torrentially deposited from broken and disintegrated rock masses, such as are now found in the streams which radiate from the Dominion Dome of the Klondike mining section.

The rocks of the southwestern section of the Klondike district are a mixture of quartz, quartzite, sandstone, limestone (possibly cretaceous), and sericite-mica schist, in contact with clay beds, lignite seams, rhyolite, andesite and conglomerate (of the Eocene of the Tertiary) all in irregular mass and in no well-defined vein form. There is also a boldly intrusive and irregular, isolated upthrust of granite (possibly Archean) surrounded by various kinds of metamorphic granites, porphyrites, and silicates, just north of the mouth of the Indian River. Below the mouth of Sulphur Creek is found a small amount of true diabase, together with both quartz and quartz porphyrite. At the town site of Dawson on the Yukon River is a serpentine diabase, metamorphic diabase, and a peridotite serpentine, forming huge bluffs, opposite, along, and below the town site.

Throughout the mass of the central area of the Klondike mining section, striking northwesterly and southeasterly from near All Gold Creek, and thence *via* Dominion Creek and crossing the divide at Burnham Creek, is found a great intrusive mass of quartz and quartz porphyrites. This great zone of intrusive and isolated quartz dikes should be carefully investigated for veinlets and irregular masses of free-gold quartz, affording a possible valuable hard-rock mining proposition. A similar huge section of intrusive quartz and quartz-porphyrite lies between the mouth of Hunker Creek and the Klondike River, and extends up the Klondike River valley to near the point of the vast level peneplain of smoothly washed gravels, beginning about opposite the mouth of All Gold Creek in the Flat Creek valley. This section contains isolated masses of tertiary rhyolites and andesites, with also silurian serpentine peridotites, together with sands and very smoothly washed, round, flat, and ovoid pebbles and bowlders, making a character of gravel of an entirely different geological formation than what now exists anywhere on the surface of the present Klondike district. These washed and very smoothly polished gravels, pebbles, and bowlders—some of these smoothly polished bowlders and slabs of rock being as large as 3 feet by 2 feet by 5 inches to 8 inches in thickness—are a mixture of basanite, lydianite, cassiterite, magnetite, black non-magnetic hematite, together with rutile, hornblende, and ilmenite, all in such enormous quantity that they give a distinctive black color to all of the fine gravels and sands of the Flat Creek series. The lydianite and cassiterite, with the non-magnetic auriferous black hematite, are in enormous quantity. This auriferous black hematite is possibly a fragmentary condition of a former metamorphic pyrrhotite or pyrite, as a ferric sulphide. These Flat Creek gravels (Eocene of the Tertiary) contain sufficient "tin stone" (cassiterite) in the shape of "stream tin" and "wood tin," with black auriferous hematite—as an altered or metamorphic pyrite or pyrrhotite—that they eventually will be hydraulicked for their values as a by-product, for gold ore and tin stone, as well as for the small amounts of metallic gold which they contain, in the shape of grains, scales, and "dust." These gravels also contain a small amount of monazite, zircon, sapphire, pyrope, tantalic oxide, iridosmine, platinum, and scheelite.

From a topographical point of view it is distinctly evident that at one time in pre-tertiary days, the Flat Creek valley, where it now enters the Klondike valley, was then the mouth of the present Stewart River, and that this ancient Stewart River actually may have flowed into the great Klondike Lake, where now are the Klondike Flats, and the forks and bifurcations of the headwaters of the present Klondike River. These Flat Creek gravels are generally free from all angularities and crevices, and are smooth and polished, without any adhering clay, mud, or muck, thus being different from the "White Channel" (quartz and sericite-schist gravels) which usually contain much sericite mud and clay attached to them.

The Flat Rock gravels are largely of an ovoid shape, sometimes flattened on one side (thus showing a lacustrine beach origin) and of a character entirely foreign to the surface rocks of the present Klondike district.

On the right limit of the Klondike valley, extending from the Yukon River at Dawson, and crossing Rock Creek (the first great fork of the Klondike River) is found another section of quartz and quartz porphyrite.

together with seams and masses of sandstone, with lignite, clay beds, and metamorphic granitic porphyrite.

The geological area of the Klondike region is therefore composed of a quartz porphyrite for its central section, and is bounded on the north by sericite-mica schist, diabase, limestone, serpentine, and quartz.

On the east the Klondike region is bounded by andesite, rhyolite, diabase, conglomerate, sandstone, clay beds, seams of lignite, great peat bogs, and the enormous "peneplain" deposit of Flat Creek "washed gravels," from rocks which are entirely foreign to the local deposit-environment.

On the south, the Klondike region is bounded by a great mass of silicified and brecciated Tertiary conglomerates, with andesite, rhyolite, and quartz with quartz porphyrite, together with limestone, altered rhyolite, seams of lignite, clay beds, and sandstone.

On the west the Klondike region is bounded by a mass of granite, with metamorphic granites and quartz porphyrites, together with limestone, rhyolite, andesite, trachyte, agglomerate, and veins of silicite or quartz.

The great intrusive and isolated zone of dikes of quartz, that breaks into the central area of the schistosic and porphyritic rocks of the Klondike gold-placer region, from near the head of All Gold Creek to Burnham Creek *via* the left limit of Dominion Creek, is a valuable district for prospectors to study for deposits of vein quartz containing free gold; and in possibly sufficient quantity to make its mining, as a lucrative "hard-rock" proposition, a profitable and economic venture.

Evidences of a "telluride" of gold, silver, lead, and bismuth have been found in the andesites, rhyolites, and porphyrites of the Klondike region.

It is possible that more careful prospecting below the thick carpet of moss, sphagnum, and erica, in the great forest growths, may yet uncover dikes and zones of andesitic and porphyritic rocks, carrying sylvanite and calaverite in sufficient quantity to make the mining of such rock a profitable enterprise. However, the Klondike mining district is at present, strictly speaking, solely a placer-gold mining region; but an enormous future hydraulic and dredge mining proposition on a large scale of operations.

For the method of gold deposition in the placer gravels, see account of the "Genesis of Gold Formation in the Placer Gravels of the Klondike-Yukon-Alaska Gold Fields," to follow.

GEOLOGICAL STRUCTURE OF THE ROCKS OF THE FORTY MILE DISTRICT OF ALASKA.

The surface rocks and stratums of the Yukon River in the vicinity of the Forty Mile district in Alaska—which is adjacent to the Klondike mining region—are principally of the Tertiary of the Eocene period; although limestones, of the Cretaceous; schists, highly silicified and crystalline, of the Silurian; and cassiterite-bearing granites, of the Archean, are also found, interspersed among these tertiary rocks.

Large quantities of a mixed cassiterite and magnetite are found in the gravels of certain of the tributary streams of the Forty Mile River.

These Upper Yukon River rocks consist of diabase, metamorphic diabase, crystalline sericite-mica schist (these schists sometimes containing intrusive masses of magnetite in a variety of cassiterite-bearing gneissoid granites) together with porphyrite and quartz porphyrite interspersed with cross section dikes and veins of laminated sericite schist—possibly of Silurian date—together with andesite, rhyolite, trachyte, and some pegmatic porphyrite of Eocene date; all of which show great faulting and flexure from their original form of deposition, caused by severe seismic disturbances.

It is quite evident that these rocks were first rendered soft and plastic by seismic pressure and its resulting heat, so as to soften the rocky strata, and then were violently disturbed and thrown into their present curved, angular, inclined, and twisted positions by sudden, powerful, and pulsating volcanic activity, to account for the presence of the trachytes, andesites, and rhyolites, with aqueous deposited secondary silicites, as chalcedony and hyalite, scattered throughout the dikes and veins of the older strata and masses of rocks.

These seismic disturbances have been so severe in some places—especially at a high bluff below Eagle City near the Yukon-Alaskan boundary line—that it has caused great local torsion, stress, and displacement of the strata, as to make huge masses of rocks, twisted and buckled in all degree of serpentine angles and curves, especially at a cliff, locally named Calico Bluff.

Following the last general seismic disturbance came the local conditions for the deposition of the gold-bearing placer gravels of the Upper Yukon River and its tributaries.

GENESIS OF THE GOLD DEPOSITION IN THE PLACER GRAVELS OF THE KLONDIKE-YUKON.

We will now, from practical study of the Klondike placer gravels, endeavor to show the method of the deposition of the placer gold (or the auric content of these detrital masses of broken schists, quartz, serpentines, and silicites) not altogether from the torrential lixiviation of the rock detritus, but also by and from deposition out of a hot aqueous solution of an alkaline silicate, containing gold, iron, sulphur, and other minerals, when such solution comes into contact with acid and organic surface conditions.

Whatever gold may have been formed in quartz veins, or in quartz lodes and zones, by igneous action (as the deposition of gold with molten silicite, interpenetrating the cracks and fissures of the sheared schistosic and serpentine rocks) was no doubt precipitated in among the detrital gravels, as irregularly shaped, attrified, and water-worn fragments and crystals of gold, along with the detrital masses of broken quartz (silicite), siliceous schists, and laminated serpentines, which are formed on or near to the so-called bedrock of the valleys of the creeks, and also in the ancient lake terraces, locally called "benches."

It may have been possible that this method of gold precipitation was general all over the Klondike region; that is to say, the deposition of the gold in the gravels and detritus of the Klondike gold fields was formed by torrential lixiviation (or the washing of agitated waters) dashing, tearing, breaking, and carrying away the debris of crushed rock masses, containing reticulating veins of gold-bearing quartz, and depositing this crushed rock and quartz, as a gold-bearing detrital placer field; but upon a careful personal investigation of part of these Yukon valley creek beds, I have positively found evidence of deposition of pyrites, gold, and quartz crystals (silicite) from aqueous solutions of alkaline silicates.

Interpenetrating among the broken laminæ of scaly schists, I have found irregular shaped and unworn fragments of gold, radiating in every direction from a plexus, or common center, in lines of unbruised fragments of gold, and in such positions as could not have been possible, if they had been torrentially deposited and torrentially lixiviated.

Pyrites, whose sharp angles were exposed in all manner of irregular positions, have been found in among detrital matter on the schistosic bed-rocks, that, if they had been taken from contact with moving torrential detrital matter, would have been crushed into fragments, or at least, have worn and attrified their sharp angles of crystallization.

Gold, in crystalline form, in specimens which were found shows positively that they are pseudomorphs (or false forms) of quartz crystals, taking the shape of groups and single-apexed crystals of silica, but composed of a high-grade variety of aqueously deposited "placer gold." If these gold crystals had been torn out of the broken rock masses by the action of these agitated torrential waters, then the sharp angles of these crystals of gold should have been abraded, bruised, flattened, torn, and broken, which are not even attrified, and their planes and angles are sharp, smooth, and distinct.

Quartz, as silica (silicite), pure and crystalline, in nodules and lenticular masses, has been found in isolated conditions on the broken schistosic "bedrocks" and also in the "pay-streaks" of the placer gravels and detrital matter in the creek beds, in such positions and conditions, which definitely prove that they were deposited there after the detrital matter was formed.

These three facts cannot be disputed; and they are absolutely at variance with the theory of an entirely general deposition of quartz crystals, pyrite crystals, and the metallic gold content of placer gravels, having been deposited in the placer beds, by the torrential lixiviation of broken rock masses, through the agency of agitated, rushing waters. They must have been deposited therein by precipitation from an aqueous alkaline silicate solution containing gold, sulphur, and iron. I account for the formation of this method of placer-gold deposition, in the following manner:

At the time when the last great seismic disturbance took place in the Klondike region (possibly during the Eocene of the Tertiary) enormous gushing springs of thermal waters were volcanically pulsated and ejected from myriads of vents and fractures in the broken rock masses; and these highly heated waters under pressure contained in solution large quantities of alkaline silicates of iron, sulphur, and gold.

When these boiling alkalinely-silicated waters came into contact with the acid waters of the surface conditions in the broken rock masses—such as contact with organic matter, peat, muck, vegetation, and surface waters—an immediate electro-chemical reaction took place, by which most of the silica (quartz) would be deposited in a more or less minute crystalline condition, and a portion of the iron combine with the remaining silica (quartz) and the alkali—which in this case was mostly composed of magnesia—and be thereafter precipitated to form micaceous schistosic rocks. The remainder of the iron and the sulphur would then unite to form a "pyrite" and sometimes be highly auriferous, as a gold-bearing ferric sulphide. The gold content of the alkaline silicate solution would now be deposited, either as free, irregular shaped grains, scales, and pieces of alloyed metal with iron, copper, and silver; or else be mechanically combined with the newly formed pyrite, hematite, or limonite, to form gold-bearing iron-ores. Or, the gold content would combine with the fractures and crevices in decomposed matter of the small lodes, reticulating veinlets, irregular masses, and "chimneys" of brecciated quartz, with interpenetrated, porous and decomposed trachytes, rhyolites, and andesites, to form rocks and ores carrying metallic gold. In some instances, I have found the gold therein the porous oxidized andesite, as a "telluride," in chemical combination with tellurium and silver as a "sylvanite."

By atmospheric, fluvial, and seismic influences, the disintegrating of these aqueous-formed deposits of reticulating veinlets and irregular shaped masses of silicite and silicates with gold, together with the electro-chemical deposits of metallic gold, and caused by the intrusion of the alkalinely-silicated thermal waters containing gold, sulphur, and iron, in torrentially deposited and non-auriferous acidulated and vegetation-watered barren gravels, was undoubtedly the genesis of a very large part of the deposition of the gold-bearing gravels of the Klondike section of the mining districts of the Upper Yukon River.

And this method of gold deposition will also apply to the entire gold-bearing gravels of the Yukon River valley and the tributary valleys of Alaska and British North America.

(To be continued.)

SULPHUR AND PYRITES.

ACCORDING to Dr. David T. Day, of the United States Geological Survey, the domestic production of sulphur in the United States increased from 181,677 long tons, worth $3,706,560, in 1905, to 294,153 long tons, worth $5,096,678 in 1906. Exports were 22,237 long tons, valued at $460,435.

The sulphur industry of the United States during the last few years has been characterized by steady growth in consumption, increase in production and decrease in quantity and value of imports as a result of the development of domestic resources.

The dominating factor in the world's supply of sulphur has been the production in Sicily, which in 1906 showed a large decrease, chiefly due to the loss of the American trade through the development of the Louisiana deposits. The exports from Sicily to the United States have decreased steadily for the last four years—from 155,996 long tons in 1903 to 41,283 tons in 1906.

The pyrites production of the United States increased from 253,000 long tons in 1905 to 261,422 long tons in 1906, but the price declined from an average of $3.71 a ton in 1905 to $3.56 in 1906, causing the total value, in spite of increased quantity, to decrease from $938,492 in 1905 to $931,305 in 1906.

Pyrites burning entered significantly into the sulphuric acid business in 1882, when the product was 12,000 tons. In 1885 the product had increased fourfold: five years later it had nearly doubled again, and the increase since has been rapid. The dominant positions in pyrites supply are occupied by Virginia, California and New York.

More careful attention to waste products in copper, lead, and precious metal smelting will lead in the near future to a production of sulphuric acid in such quantities as to affect commercial conditions very appreciably, and these sources of the acid must be taken into account.

THE SUN'S MOTION RELATIVELY TO THE ETHER.

WRITING in Nature, C. V. Burton states that so far as is known it has not been pointed out that the velocity of light as deduced from the observed times of occultation of Jupiter's satellites is affected to the first order by the motion of Jupiter and the earth with respect to the ether. Taking the best times for observation, when the distance between the two planets is very nearly a maximum or a minimum, there will be no appreciable relative velocity in the line of centers and to a first approximation, the velocity with which light from Jupiter approaches us is then made up of the true propagation velocity increased by the common velocity component of the two planets in the direction earth to Jupiter. In order to determine the sun's motion with respect to the ether, the values for the apparent velocity of light deducible from the observed times of occultation might be analyzed, so as to discover any systematic differences depending on the direction of the line of centers. Only very small corrections would be needed on account of the motion of the planets relatively to the sun. The probable absolute error in the finally deduced velocity of the sun (relatively to the ether) would be of the same order as that affecting the finely deduced velocity of light. The quantity to be determined might perhaps be swamped by the errors of observation, but even so a superior limit could be assigned to the sun's velocity through the ether. Two of the three rectangular components of that velocity being measured in the plane of the ecliptic, the determination of the third component would unfortunately be badly conditioned.

THE EVOLUTION OF THE HORSE.*

AN INSTRUCTIVE EXAMPLE OF ADAPTATION.

BY B. M. UNDERHILL, V.M.D.

To read that the ancestors of our horses hundreds of thousands of years ago had three toes and were no larger than sheep may be entertaining, but unless such facts are brought into connection with principles that arrange them in their relation to other facts, they can only serve to conduct us through mere description to blank amazement. I have attempted in this brief paper to present connectedly and relatively the outlining facts which I have derived from a number of authors who have recorded the results of more recent research in the fossil fields of North America. The evolutionary line is that of Prof. Marsh, while for the description of fossils I have relied principally upon the study of specimens at the American Museum of Natural History in New York.

In America, where the record is most complete, the horse has been traced from the Mammalian Dawn down to historic times through eight successive stages without a break of importance in the line, and, as we study these steps that lead up to the most highly specialized of modern animals, with their accompanying phenomena of environment, we are furnished with the best exemplification in existence of the laws which govern animal evolution.

It is of course not to be inferred that the distinguishing characteristics in this series were abrupt departures from prevailing forms; the horse with one functional digit between two that were useless was not a direct product of the preceding genus in which the two lateral hoofs reached the ground and contributed to support, nor did this three-hoofed horse thus descend from the one which stood upon four. Between these stages there was an intermediate series in which the tendency to discard what had become an incumbrance went hand in hand with adaptive development.

As an example we may take the case of the so-called wolf-tooth of our present day horses. In the ancestral types this first of the four premolars was fully developed and had its opposing tooth in the lower jaw. As the lower tooth was the first to go, the atrophy of disuse attacked the upper one, though it remained constant for a long period of time. Then an occasional individual appeared without it; later as many appeared without it as with it, and still later it had disappeared from almost all and became very rudimentary as at present. The process of discarding this tooth absolutely has already occupied a period of probably not less than 50,000 years, and it is still unaccomplished. Thus it will be clear that in the slow progress of evolution a long series of related forms must have intervened between the stages that we recognize as genera.

Figuratively speaking, our highly individualized animals of to-day represent the topmost twigs of a tree. In the preceding branches there is a tendency to combine these characteristics in more comprehensive types, and we find ancestral forms the more generalized as we pass downward toward the trunk. At the point where we meet the first Ungulate we find evidences that a branching has already taken place into odd-hoofed (Perissodactyla), where the middle toe is the center of support, and into pair-hoofed (Artiodactyla), where the support is distributed between the middle and fourth. The paleontologist can by most probable outlines trace these two groups to the present, where they reach their highest expression in the horse and ox groups.

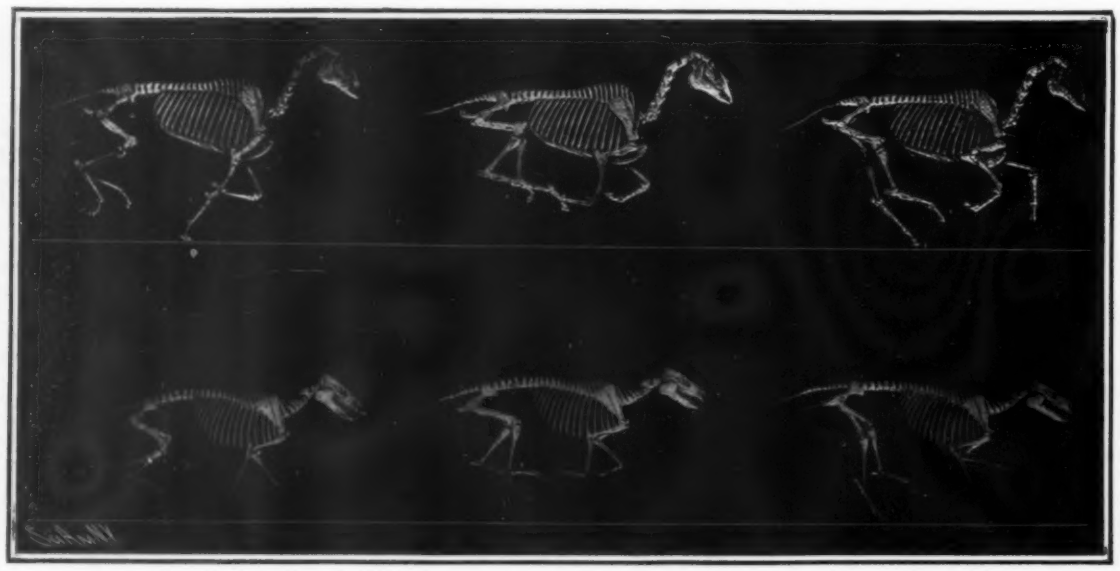
THE FIRST PRIMITIVE FOUR-TOED HORSE. SIXTEEN INCHES HIGH. FROM A PAINTING BY CHARLES R. KNIGHT.

Over forty years ago a skull was found in the Lower Eocene of England belonging to an animal which was at that time named Hyracotherium by Prof. Owen and which has since been recognized by paleontologists as representing the most primitive stage known in the horse's ancestral line. The molar teeth have six cusps on the upper and four on the lower ones, and these are just beginning to fuse into crests. In each jaw the fourth premolar had three cusps, the third two, and each of the first and second premolars one. The teeth are short crowned and like those of omnivora. The fact that this skull is more primitive than any yet found in America would seem to indicate that the original stock was Eurasian, and that it migrated eastward, by land connections then existing, to North America, here to continue its evolution. The succeeding genera in North America are increasingly numerous, while in Europe the line is disconnected, its occasional representatives probably being derived from those that had found their way westward from this country.

The American series starts with the Eohippus, or "Dawn Horse." It comes from the Lower Eocene of Wyoming and New Mexico, and is much more available for study than the Hyracotherium. It is about the size of our domestic cat, and is like the Hyracotherium except that the fusing of the cusps into crests has progressed and the fourth premolar is beginning to look like a true molar. The hand of this animal has four functional fingers, while the thumb is rudimentary and reduced to a splint. The foot has three functional toes, no trace left of the first toe, and the fifth reduced to a splint. It might be explained parenthetically that terms applied to the human digits are used here in describing the front feet in order that we may more readily follow these changes by reference to our own fingers.

The second in the series is the Orohippus, or "mountain horse." It is found in the Middle Eocene of Wyoming, and in size is somewhat smaller than a fox. Like the Eohippus it has four functional fingers and three functional toes, but the splint of the thumb has disappeared, as has the splint of the fifth toe. The radius and ulna and tibia and fibula are still distinct. The crests on the molars are clearer than in the preceding stage and the last premolar is like the true molars, while the next to the last is beginning to become so. The canines are well forward and the diastema, or "place for the bit," is distinct.

The Epihippus is from the Upper Eocene, and is about as large as a fox. In this stage the four fingers and three toes of the Orohippus are still retained, but the central finger and central toe are becoming larger. The once rounded knobs of the molar teeth are now



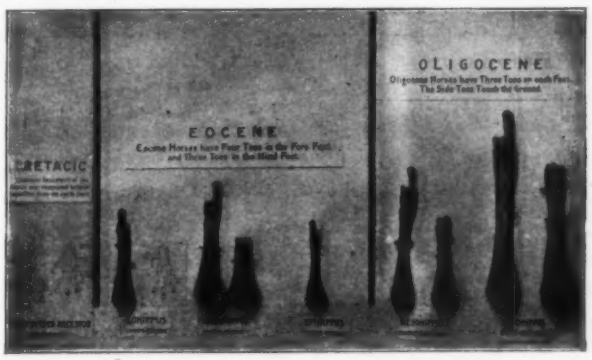
SKELETONS OF THE MODERN HORSE (ABOVE) AND OF THE SMALL FOUR-TOED HORSE (BELOW), SHOWING THE SUPERIORITY IN STRENGTH OF LIMB OF MODERN HORSE.

THE EVOLUTION OF THE HORSE.

* Abstracted from a paper read before the Keystone Veterinary Medical Association of Philadelphia.

almost completely converted into crests, while the third, as well as the fourth premolar, have become like the molars.

The fourth in the line is the Mesohippus, found in the Lower Miocene White River formation. It is somewhat smaller than a sheep, and stands upon three



DEVELOPMENT FROM FIVE TOES TO THREE TOES.

fingers and three toes, the fifth finger of its Eocene ancestors being reduced to a splint. The side digits are now bearing little weight, while the central ones are much the largest. The crests on the molars are completely formed and three of the premolars have become true molars.

The Miohippus from the Upper Miocene is about as large as a sheep. Like its predecessors in the series, it has three fingers and three toes, a rudiment of the fifth finger still remaining. The radius and ulna are loosely united, and the tibia and fibula are co-ossified at their distal ends.

The Protohippus is found in the Lower Pliocene. It is nearly as large as an ass, and represents the first stage where the lateral hoofs are not functional. It stands upon the middle finger and middle toe. The side digits, that is, the second and fourth, are still complete, but much more slender than in the preceding stage, and they are clear of the ground. The hand still retains tiny nodules of bone at the back of the wrist, or so-called knee, which are the remains of the first and fifth digits.

In the Pliohippus from the Upper Pliocene, we have the last stage before reaching the true horse. It is as large as an ass, and in some species the side digits have almost if not completely disappeared.

The last in the evolutionary line is the genus *Equus*, which is first met with in the Upper Pliocene, an animal in all essential details of structure similar to our modern horses.

Briefly reviewing this co-ordinating degeneration and development in its relation to environment, there appears a remarkable example of the power of the animal organism to keep pace with changing surroundings in adapting itself to new requirements. At the beginning of the age of mammals, where we find the four-toed Eohippus, the North American climate was tropical, and dense forests covered the greater part of the country; the ground was moist, and there was an abundance of tender, green food. The spreading, lateral toes of the little primitive horses were well adapted to the soft turf; their short, tuberculate teeth were sufficient for the tender herbage, and the dense, tropical vegetation offered them protection against their enemies. Horse and climate now evolve together, the continent is steadily rising, the forests become thinned, the land is getting drier, the climate colder, and beasts of prey are becoming more formidable and swifter of foot. The animals must adapt themselves to these changed conditions or become extinct. The ancestors of the horse take the former course; they become larger, the lateral elements of the limbs fall away while the axial ones develop, giving more speed and a foot better fitted to the harder turf of the more elevated land. The neck and head are elongating to conform to the increasing height, while the teeth gradually lose their omnivorous characters and become adapted to the tougher grasses of the plains. And so it all goes on through the Tertiary Age. It would appear that the horse develops with the plains until, when we reach the beginning of the Quaternary, we find him one of the most specialized of animals in his adaptation to these plains which have become his natural environment.

During an expedition sent out by the American Museum of Natural History into Northern Texas in 1899, there was found, among fragments of others, a complete skeleton of one of these Pleistocene horses, which represents the last of its race in America. There are no features in this skeleton to distinguish it generically from that of existing species. It is somewhat larger than the zebra, with bulging forehead, short neck, rather long body, and short legs. The lateral digits of its ancestors are gone from both front and hind feet, and there are two rudimentary metacarpal and two rudimentary metatarsal bones. The dentition is three incisors, one canine, three premolars and three molars on each side above and below, making forty teeth in all. The first of the four premolars of an earlier stage having disappeared from the lower jaw, its corresponding tooth above has ceased to be functionally developed, and the remaining premolars have assumed all of the characters of the true molars.

It is this horse that before the great ice sheets covered the northern parts of North America and Europe, roamed over the open lands of all the continents except Australia and then, during the glacial period, became extinct in America and later disappeared from the scene in Europe. Here his trail sinks beneath the geological horizon just as the first scratchings and chippings of man are appearing above it. Why, we do not know. It has been assigned to the ice during the

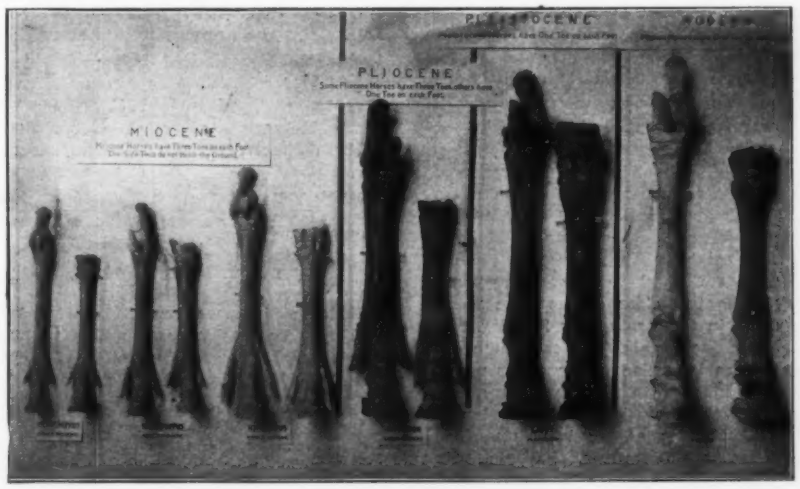
THE WILD HORSE OF ASIA. THE LAST LIVING ANCESTOR OF THE MODERN HORSE.

glacial period, but they also became extinct in Central and South America, where there was no ice sheet, and survived in Europe until the postglacial. But we might now be in a horseless age indeed had not a sufficient number of species survived in Asia and Africa to continue the line, and to-day we have the horse, the ass and the zebra—three branches that have come down to us from this prehistoric wild horse. These descendants are still to be found in Asia, where we have Przewalsky's wild horse, of which little is known, and the Asiatic wild ass; while in Northern Africa we have the African wild ass, and in the south of that continent there are several species of zebra. The so-called wild horses that until recently roamed the plains of North and South America were feral, that is, they were not truly wild, but were the descendants of domesticated horses brought here by Europeans and abandoned. That these three branches sprang from a remote common parentage is pretty well proven by similarity in striping. The ass and zebra show the strong black stripe which occasionally crops up in our domestic horses, the circular leg stripes rarely showing in all three.

It is inferred that the Old World horses came from America because of their appearance in England, Northern Italy, and Northern India in the same geological period in which they are found so abundantly in America, and also from the fact that a distinct connecting link between this horse and his three-toed ancestors has been found only in America. The fact that the camel appears simultaneously with the horse in the European series, lends support to this conclusion, as there is no doubt that the camel is an exclusively American-bred animal, sharing the pregiacial uplands with the horse, and it is most likely that he migrated to the Old World at about the same time. At the end of the Tertiary Age the continents stood higher above sea level than at present, and the plains, with their covering of grass, had come into existence. At this time there was land connection between North America and Asia, and it is then that our American wild horses are supposed to have started on their journey to the Old World.

Though man probably lived in Western Europe before the Ice Age, no trace of him has been found associated with the remains of the pregiacial wild horse. Postglacial man came in contact with him in Europe, but they had become extinct in North America before its supposed colonization by the original inhabitants of Asia, though in South America there are indications that they persisted until man's advent. It is in the Rough Stone Age that the remains of horse and man are first found together, and, as they are here associated with chipped stone implements, fire debris and pottery, we conclude that the horse was at that time hunted and eaten by this cave-dwelling man. The taming and breeding of horses did not take place until thousands of years after man and horse first came together. They were probably first domesticated in Central Asia and North Africa, but are not represented upon Egyptian monuments earlier than the eighteenth dynasty. The first Spanish explorers to the New World found no horses and the Indians knew nothing of them either by contact or tradition, yet when the horse was reintroduced to this country by the white men in the sixteenth century, he thrived and increased, showing how well he was adapted to the native home of his ancestors.

As man's companion in the harness of civilization we find the modern horse almost perfect in his adaptation to his native habitat, yet the rudiments of his conformity to a tropical environment still linger, and it is not quite correct to say that the lateral hoofs have absolutely disappeared. It is thought by some that the chestnuts, or horn-like processes on the fore and hind legs, are the remnants of the first digits; others regard them as the remains of cutaneous glands, which seems less likely, but any doubt that in the horn-spurs of the fetlocks we have the coalesced second and fourth hoofs should be cleared away by recorded cases of reversion to the three-hoofed type, in which the horn-spurs are entirely absent. Nature is slow to get rid of these vestiges while they do no harm, but, as the hard ground crust or frozen snow of the northern plains would frequently tear the spurs from their attachments, and the consequent bleeding make the wild horses an easier prey to their carnivorous enemies, they should, in the course of adaptive modification, be discarded, and this is exactly what has occurred in the case of the Celtic pony of Iceland, which represents in this and in some other respects



DEVELOPMENT FROM THE MIOCENE THREE-TOED HORSE TO THE MODERN ONE-TOED HORSE.

THE EVOLUTION OF THE HORSE.

the highest degree of specialization yet reached by any member of the horse family. Though we might naturally look upon our modern wild horses, asses, and zebras as the nearest to the primitive equine type, this is only true as to colors and conformation. Here we have the retention of those features most suitable to an environment that is but little changed, while the discarding of the useless remnants of primitive organs has made the greatest progress because there has been no interruption; natural selection has not given place to artificial selection, and the line remains unbroken. It is among our domestic types, produced by cross-breeding, that we find tapir-like muzzles and the most prominent fetlock spurs and chestnuts; crossing tends to atavism, and the more the bloods are mixed, the more gross become these ancestral vestiges.

In any age in which he may be found, the horse, wild or domestic, will possess some characters of a group which predominated in a former age, united with some characters of a group not yet in existence, and with these characters possess those of a group already existing. Thus he clearly demonstrates a principle applicable to the evolution of all animal life.

SCIENCE NOTES.

According to the figures for 1902—the latest available complete ones—technical instruction is on the increase in Germany. A comparison between the figures of 1901 and 1902 shows that the attendance at the twenty-two universities increased from 27,398 to 35,857, or 31 per cent. At nine technical high schools the figures show an increase from 4,209 to 13,152, or 213 per cent; at nine agricultural and veterinary schools, from 1,741 to 2,400, or 38 per cent; at three mining schools, from 289 to 879, or 204 per cent; while at the five forestry academies the attendance fell off from 280 to 251, or 10 per cent. Taking the entire list, there was a total increase from 34,017 to 52,538, or 54.5 per cent.

A detailed description of the new photographic equatorial reflector recently installed at the Khedival Observatory at Helwân, Cairo, is given by J. H. Reynolds in the monthly notices of the Astronomical Society. The aperture of the mirror (made by Common) is 30 inches, and the instrument is arranged on the Newtonian form with a small flat at 45 deg. to the main axis. The photographic plate is provided with the well-known slipping-plate motion devised by Common. The chief work proposed for the instrument is nebular photography, especially of the region lying between the equator and 40 deg. south declination. It is intended to add a good finder, so that cometary photography may also be done.

Walker and C. Hill in a paper read before the American Society for Testing Materials say that specimens of Swedish iron were strained in tension while forming one electrode in a cell in which the other electrode was normal calomel, and the electrolyte ferrous sulphate. Generally the potential-change below the elastic limit was less than 0.0001 volt, and did not exceed 0.0004 volt. This should have no appreciable effect on corrosion; the strained metal had a somewhat slighter tendency to corrode than the unstrained. Beyond the elastic limit the potential rises suddenly several hundredths of a volt while loading, but falls upon unloading. Similar phenomena were observed under torsional stress. Out of a number of specimens strained to rupture, the potentials of six attained a constant value after fracture. The differences between initial and final potentials ranged from 0.0019 to 0.0077 volt. It is concluded that even when strained beyond the elastic limit the corrosion of iron is but little different from the normal.

Goldstein's canal rays (Kanalstrahlen), which at suitable pressures visibly stream through the apertures in a perforated kathode, backward away from the anode, according to A. A. Campbell Swinton, share with kathode rays the property of producing a sufficient mechanical pressure to cause small and light mica mill-wheels to rotate. The best results are obtained with medium vacua, when the canal rays are highly luminous. The two sides of the mica vanes were found to differ in temperature by 200 deg. and the effect is probably due to this. The maximum difference of temperature took place at pressures which gave a maximum luminosity to the canal-rays and a maximum velocity to the mill-wheel. The canal rays are supposed to be streams of positively electrified particles which, traveling toward the kathode, pass through the apertures in the latter, and emerge on the other side. These mill-wheels would appear to demonstrate the motion of these particles, both when they are approaching the kathode and after they have passed through the latter. Canal rays make lithium chloride fluoresce red; kathode rays make it fluoresce blue. The force exerted by kathode rays is greater than that exerted by canal rays; but if the mill-wheel be made of aluminium there are opposite results, further to be studied, which point toward the influence of conductivity for heat tending to equalize the temperatures of the two sides of the metal vane, as contrasted with the mica vane.

TRADE NOTES AND FORMULÆ.

Production of Chrome Ocher for Floor Varnish Paints.—Natural ochers, even the purest and best, often do not meet the requirements as to color, tone, and brilliancy; they are more likely to be, in most cases, dull and are frequently combined with chrome yellow, for the production of floor varnish paints before being ground in varnish. It has been found, however, that the color tones obtained in this manner are very much more brilliant, when we do not rely on a mechanical mixture, but precipitate on the ocher, in a finely-divided condition in water, the chrome yellow from a mixture of bichromate of potash and acetate of lead. Exactly the same process is to be followed as in the production of chrome yellow alone. We require for the preparation of the chrome ochers large tubs, as well for the elutriation of the ocher with water as for the solution of the chromate of potash and sugar of lead, apparatus for pressing out the deposited coloring substance and apparatus for drying the moist material. The drying apparatus consists best of frames, under a roof, on which the boards with the material to be dried spread on them, may be placed. Under the influence of air currents and warmth it speedily dries and is then pulverized with the aid of an edge mill or ball mill and finally sifted. In the very light varieties, white lead is used for brightening purposes; in the reddish kinds, besides burnt ocher, Pompeiian red and fine English red are used, while the dark shades are produced by the addition of catechu. The method is as follows: The body colors (ocher, white lead, burnt ocher) are placed in a large tub, the necessary quantity of water poured in, and the whole worked over, so that a thick paste is produced. It is best to pour the water over the powdered material in the evening, allowing it to stand all night, and the next morning work it up thoroughly. Then the separately prepared solution of bichromate of potash is introduced into the mass, and thoroughly worked in with paddles, with occasional pauses, and after two hours the sugar of lead solution, also separately prepared, is likewise admitted slowly and thoroughly stirred into the mass. Chrome yellow is at once separated in a very finely divided condition, which settles alongside of the ocher particles, but does not envelop them. Thorough mixing completed, the mass is left to stand, so that the body color may settle. By means of a vent, placed at the right height, the water is drawn off, replaced with clean water and the whole thoroughly mixed up again and allowed to settle, fresh water is repeatedly introduced, until it contains no more salts. The contents of the vat are then left to afford the body color an opportunity to settle compactly, the water is drawn off and the color transferred to draining cloths or to a filter press. The latter of course removes the water in a shorter time and much more completely. The chrome ocher is obtained in the form of more or less solid cakes or as a thick paste; it is placed on the drying boards, and left to the drying process. In place of white lead, we can use the much cheaper sulphate of lead, of which, however, owing to the fact that its covering power as well as its color-lightening capacity is considerably inferior, a larger quantity than of the former must be used.

Catechu must be washed into water and carefully freed from any solid particles (leaves, skin, etc.) added after the precipitation of the chrome yellow and thoroughly mixed with the entire mass.

Following are the proportions to be used:

1. The Lightest Kind of Chrome Ocher.—240 parts by weight of ocher; 300 to 400 parts by weight of water; 108 parts white lead (or sulphate of lead); 14 parts bichromate of potash, 48 parts of sugar of lead, both dissolved in the least possible quantity of water.

2. Fiery Yellow Chrome Ocher.—200 parts by weight of ocher, 400 to 500 parts of water, 14 parts by weight of bichromate of potash, 48 parts by weight of sugar of lead, both dissolved in the least possible quantity of water.

3. Reddish Chrome Ocher.—300 parts of ocher, 400 to 500 parts by weight of water, 20 parts by weight of Pompeiian red, 16 parts by weight of bichromate of potash, 38 parts by weight of sugar of lead, both the last dissolved in the least possible quantity of water.

4. Red Chrome Ocher.—300 parts by weight of ocher, 450 to 550 parts by weight of water, 48 parts by weight of Pompeiian red, 14 parts of bichromate of potash, 38 parts of sugar of lead, and 72 parts by weight of catcheu solution, made up of 16 parts by weight of catechu and 56 parts by weight of water.

5. Red-Brown Chrome Ocher.—300 parts by weight of ocher, 500 to 600 parts of water, 56 parts by weight of Pompeiian red, 14 parts of bichromate of potash, 38 parts by weight of sugar of lead dissolved in the least possible quantity of water, 90 parts by weight of catechu solution, made from 24 parts by weight of catechu and 60 parts of water. With the last named ingredient fine wine black (6 to 8 parts by weight) can ultimately be added.—Farben Zeitung.

ENGINEERING NOTES.

According to the Engineering and Mining Journal an excellent self-lubricating non-shrinking packing for high-pressure steam, hot water, locomotive, and stationary engine throttle valves should be made of twisted strands of pure asbestos, braided and combined with waterproofing material, vulcanized, and coated with plumbago.

The government of Holland has drafted a bill for the reclamation of 40,000 acres of fertile land from the Zuyder Zee. This land has been flooded by the incoming ocean, but the depth of water is only a few feet, and it is believed that the land can be recovered at a cost of $11,200,000 and seven years' work. This seems an immense cost for land when we think of the millions of acres of virgin soil still waiting to be cultivated. But the reclaimed soil will be rich and suited to garden truck, and with the rich markets of England within convenient reach, will doubtless pay a good return on the capital invested in it.

An English steamship on her arrival at New York on November 6 was found to be in flames. Her cargo was wool, hemp, matting, and tea, and was worth several hundred thousand dollars. A fire extinguisher that generates carbonic acid gas was put into service on one side the ship, while fresh air was pumped out of the hold on the other side, the fire-destroying gas taking its place. As the air was exhausted the smoldering cargo was gradually choked, and after the carbonic acid gas had been left in the hold a few hours, the hatches were opened and no traces of live fire found.

The Engineer gives an interesting comparison between an old beam engine and the turbo-generator which has recently replaced it in some large cotton mills at Fairfield, England. The conversion from steam to electric driving was made under the difficult necessity of keeping the mill in operation during the change. The mill is now driven by twenty-four motors aggregating over 1,000 horse-power, and is also electrically lighted. The engine room of the generating plant formerly contained an old beam engine, erected in 1834, to drive the mill, and later converted into a pumping engine. In its place a 1,000-kilowatt steam turbo-generator forms a striking contrast. The old engine weighed about 100 tons, and ran at 23½ revolutions per minute, the new one weighs 20 tons, and runs at 1,500 revolutions. The old engine occupied 38,500 cubic feet, the new one only 24,000 cubic feet, or three-eighths less.

In a paper read before the Liverpool section of the Society of Chemical Industry, F. J. Brislee applies Boudouard's investigations of chemical equilibrium to the reactions taking place in a locomotive boiler firebox under the conditions found there, and the application of Le Chatelier's equation, with Kirchoff's expression of the law of change in the heat of reaction with temperature, to the calculation of the ideal composition of the gas resulting from combustion of carbon is shown. The ratio C_{co}/C_{co_2} gives the ratio of weight of partially burnt carbon to that completely burned, and the ratio $CO/(CO + CO_2)$ is a measure of the carbon partially burned compared to the total amount consumed. For efficient combustion these two ratios should be as small as possible, the maximum being reached when they are both zero. When combustion takes place in air (21 per cent oxygen and 79 per cent nitrogen) the proportion of CO can vary between 0 and 34.71 per cent, while the CO_2 can vary between 0 and 21 per cent. When coal is used the percentage is usually between 9 and 14. The effects of uniform size of pieces of fuel and of the velocity of the current of air or gases through the fire are considered, and nine tables are given of analyses of the gases drawn from the smoke-box under varying conditions of speed of engine and vacuum in the smoke-box. A steady current of air in sufficient amount to produce the most suitable velocity of combustion gives the best results.

TABLE OF CONTENTS.

PAGE

I. ASTRONOMY.—Navigating without Horizon.—By Capt. BRADLEY A. FISKE. 405
The Sun's Motion Relative to the Ether. 411

II. CHEMISTRY.—Synthetic Camphor. 407

III. ELECTRICITY.—Notes on Tuning in Wireless Telegraphy.—5 illustrations. 406

IV. ENGINEERING.—An Indian Cantilever Bridge.—5 illustrations. 401

V. GEOLOGY.—"Breathing Wells" in France. 405
Report of the Geological Formation of the Klondike.—By Dr. WILLIS EUGENE EVERETTE. 410
Sulphur and Pyrites. 411

VI. MECHANICS.—Manufacture of Boiler Tubes.—By F. N. SPELLER 402

VII. MINING AND METALLURGY.—The Problem of the Metalliferous Veins.—By JAMES FURMAN KEMP. 403
The Electrolytic Theory of Corrosion. 404

VIII. NAVAL ARCHITECTURE.—A Torpedo Boat Driven by Kerosene.—2 illustrations. 405

IX. PALEONTOLOGY.—The Evolution of the Horse.—By B. M. UNDERHILL, V.M.D.—5 illustrations. 412

X. PHYSICS.—Some Properties of Electrons. 406

XI. TECHNOLOGY.—Etching. 407

The Scientific American Supplement. Index for Vol. 64.

JULY—DECEMBER, 1907.

The * Indicates that the Article is Illustrated with Engravings.

A

Abutments, concrete..... 41
Accumulator cars, German....*302
Accumulators, new containers for.400
Adhesive from moss..... 96
Adhesive, insoluble..... 51
Aeronautical observatory.....*24
Aeroplane, the..... 90
Aeroplane, Bleriot's experiments.*168
Aeroplane, Farman's record.....*290
Air compressor, new centrifugal.*237
Air in New York Subway..*164, 165
Air, vitiation of.....207
Airship, defects in British.....*379
Aizani, temple of..... 79
Albumen, bleaching of..... 59
Albumen, blood..... 48
Alcohol lamps.....*180
Aluminium castings, cracking of.328
Alcohol, denatured, situation...392
Alcohol for operating engines....306
Analysis of bread and wheat.... 39
Ancients, color sense of the..... 46
Animals, heart weights of.....162
Animals, passing of the..... 59
Ant pest in New Orleans.....137
Anthropological curiosities..... 99
Arc lamps.....*293
Arc lamps, new developments in *141
Archeology in Chaldea.....253
Archeology, Roman cities in Africa *225, 232
Archeology in Spain.....*300
Arithmetician, a remarkable..... 93
Armored war vessels, development of .. *131, 151, 170, 178, 205, 218 238, 245, 266, 276, 291, 308 332, 342
Arsenic industry of Cornwall, *209, 210
Asbestos 194
Astronomy on Mont Blanc.....335
Astronomy, recent progress.*193, 200
Atmosphere of cities..... 10
Atoms, disintegration of.....*174
Audion, the *348, 354
Autogenous welding of metals... 38
Automobile: German fire apparatus *136
Automobile motor starting devices *68
Automobile race, Grand Prix....*50
Automobiles at Paris show....*396
Autotractor *364

B

Bacteria, purple.....335
Balloons and lightning.....103
Balloons, army dirigible *408
Balloons in warfare.....*305, 312
Bamboo, paper pulp from..... 11
Barrels, manufacture of.....246
Battery development, storage....326
Battery, improvements in.....*124
Battery tunnel, New York.....264
Battleships, gun distribution, *44, *52
Beaufort sea.....366
Belting, to preserve.....240
Bird of prey, biggest.....366
Birds that kill snakes.....351
Biscuits, English..... 16
Blast furnace, modern American 242
Blasting mixture..... 91
Bleaching vegetable fibers..... 12
Bleriot's aeroplane trials.....*168
Blood albumen..... 48
Boat, torpedo, kerosene-driven..*405
Boiler capacity, to increase.....347
Boiler tubes, manufacture.....402
Boilers, superheating of marine steam 186
Bonbon making..... 32
Book worms..... 64
Bookbinders' waste.....235
Bororo Indians.....*316
Bouillon soup tablets..... 48
Boule furniture, imitation..... 96
Brain, left half of.....*251
Brake, eddy current.....*295
Brass waste.....267
Bread and wheat, analysis of... 39
Breathing of plants.....255
Breathing wells in France.....405
Brewing, residual products.....211
Bridge, an Indian cantilever, *401, 402
Bridge across Rhine.....*328
Bridge, derailment on..... 64
Bristles and whalebone, substitutes for 80
Bristles, bleaching of..... 58
Bristles, to color black.....112
Britannia metal..... 64
Bronze imitation in plaster..... 64
Bronze liquid..... 64
Bronzing for iron wire.....384
Building a liner.....*337, 344
Burns, salve for..... 63
Butter powder..... 74

C

Cable-assisted trains.....*216
Cable ship, a new.....*369, 377
Cable, submarine, vicissitudes..400
Cactus, cult of the.....*220
Calcium 296
Cameos, imitation..... 80
Canned meats 395
Caramel coloring..... 96
Car, slag.....*61
Carmine 96
Carmine solution.....112
Carrier pigeons on Congo.....375
Cars, German accumulator.....*392
Caseine, industrial uses of..... 89
Cathode rays and aurora.....295
Cave cathedral, Mammoth.....*125
Cedar wood imitation..... 96
Celluloid, to dye.....112
Cement, Carlsbad patent..... 80
Cement, diamond 400
Cement for precious stones.....*384
Cement, qualities and usage.....290
Cement, white.....239
Census, metal working machinery 159
Cerophanies 112
Chalk, London..... 32
Cheese, Roquefort..... 51
Chemical progress 250
Chemistry, problems of applied..370
Chicago a port..... 16
Chlorophyl 80
Circuits, grounding secondary alternating 80
Cleaning plant, automobile..... 4
Climate, psycho-physical aspect of 19
Clock, largest in France..... 58
Clocks, ancient and modern.....*109
Coal in Pennsylvania in 1906...175
Coal mined by machines.....271
Coal production 366
Coal, spontaneous ignition of.... 23
Coal washing tests..... 185
Coaling vessel, self-propelling, *177, 178
Coalite 50
Coast erosion.....198
Collier, new type of.....*265
Color photography *217
Color photography, Lumière process 62
Color photography, new method..383
Colors, primitive of the Greeks.. 80
Color sense of the ancients..... 46
Column, Trajan's..... 31
Colzi sun prism.....*254
Commerce of U. S. by ports and sections 135
Compass, liquid..... 29
Compressibility of water.....272
Concrete abutments..... 41
Concrete, effect of water used in. 64
Concrete, action of seawater on..378
Concrete construction, to prevent failure 226
Concrete, reinforced beams.....330
Coney of the Bible.....382
Control for magneto.....*198
Copper casting.....281
Copper, recovery from scrap.....246
Copper refining machinery.....*42
Corn and products, food value of 87
Coronium 256
Covers, composition for..... 80
Crane, an articulated.....*385, 386
Cranes, floating.....*36, 273, 279
Crete, excavations in.....*34
Crime detector, scientific.....363
Curry powder.....112
Cymometer *60
Cylinders, interchange of heat in.187

D

Degras 409
Diamonds in Arkansas.....211
Diamond cutting in Amsterdam..278
Dip needle demonstration.....*343
Discus thrower, the.....*253
Distances and heights, estimating *108
Distillation of soft wood.....275
Diving, limit of deep-sea.....399
Divining rod.....288
Dock, floating, for Trinidad.*129, 130
Dust preventing in grinding trades *310
Dyestuffs from waste products...363
Dynamite, facts about..... 35

E

Earth, age of the.....331
Earth's consolidation, age of....366
Earth's interior..... 63
Earth, shape of the..... 79
Ebonite, to make.....384
Ebony, artificial.....384
Eburin, imitation.....379
Edison's secondary battery.....*124
Egyptian excavation.....207
Egyptian Lourdes, an.....*259
Eggs, soft-shelled..... 23
Electrons, some properties of...406
Electric food warmer..... 64
Electric locomotives for coal mines 32
Electric railway, Munster Schlucht 16
Electric railroad in Petersburg..313
Electric wave telegraphy.....*189
Electric waves and meteorology..382
Electrical devices, three new.....*85
Electrical engineering elements, *197, 228, 268, 293, 324, 356, 390
Electrical slide wire bridge.....*244
Electrically propelled vessel..... 48
Electricity, smelting by..... 48
Electrolysis problem, an.....128
Electrolytic theory of iron corrosion *138, 148
Electrons, properties of.....100
Electrolytic rectifier..... *5
Engines, Luderitz..... 16
Epidemics 55
Eraser, lead pencil..... 16
Etching 407
Ether density.....212
Eucalypts of Australia.....350, 367
Evolution and tertiary mammals.223
Excavations in Crete.....*34
Expedition, George..... 9
Explosives, dynamite..... 35
Exports, Chinese.....375
Exports, electrical.....100
Exports, manufactured.....154
Eye, effect of light on.....312

F

Fan, portable..... 47
Farm motor, a successful.....*364
Ferro-concrete for foundation caissons *236
Fertilizers, artificial..... 13
Fertilizer from house refuse.... 98
Fiber, maguay.....*97, 98
Fiber, Mexican bromelia.....143
Figs, French..... 32
Files, rejuvenation of..... 39
Finland, electrical imports..... 95
Fire apparatus, German automobile *136
Fireboat protection *329
Fish and their eggs.....314
Fish, manometric apparatus....*301
Fish that hatch eggs in their mouths *260
Fishes, fins of..... 80
Fishes, venomous.....*12
Fishing lines, preserving..... 21
Flame as motive power.....378
Flame, study of.....303
Flashlight powders..... 19
Flour, aging of.....179
Flour, causes of quality.....191
Flowers, nuptials of the.....*56
Fluorspar 199
Fog, dispersion of..... 30
Food warmer, electric..... 64
Forging of alloy steels.....311
Freezing of wells.....313
Freight trains, heavy.....119
Frost prevention on shop windows 375
Fuel testing at Jamestown.....*140
Fulton and the sidewheel.....*282
Fulton centenary.....*173

G

Galvanizing, art of.....21, 42
Gas and hygiene.....274, 299
Gas engines, large marine..... 83
Gas engine valves.....340
Gelatine, bleaching of..... 59
Geology, glacial..... 77
Geology of the Klondike.....410
George expedition..... 9
German transatlantic enterprise..166
Germs and sunlight.....171
Gilding, methods.....240
Glacial geology..... 77
Glue, bleaching of..... 59
Gold ship, modern..... *3
Grafting wax..... 16
Gravity decomposition *399
Gun distribution aboard battleships *44, *52
Gypsum plaster..... 18
Gyroscope, the.....*82
Gyroscope, theory of the..... 26

H

Hagenbeck's new zoological park, *81, 88
Heart weights of animals.....162
Heating of houses: automatic control *212
Heights and distances, estimating *108
Helion filaments 327
Hertzian waves, distant operation by *150
Heveas 32
Honey, sources of.....*92
Horn waste.....275
Horse, evolution of the.....*412
House heating: automatic control *212
Hydroplane, Santos Dumont's...*264
Hygiene in European schools....381

I

Ice cream, lead in..... 19
Ice houses.....*188
Imports, electrical, to Finland....95
Imports, United States.....107
Improved material for machinery.402
Incandescent illuminants.....139
Incandescent lamps.....223
Indian cantilever bridge..*401, 402
Indians in Brazil.....*316
Induction coil design.....*213, 230
Induction principle, wireless telephone on.....*37
Infusorial earth waste.....341
Insects, venomous.....*28
Insecticides 32
Insulators, new.....*85
Iron corrosion, electrolytic theory *138, 148
Iron hands.....*284
Iron rust, electrolysis, cause of.. 74
Iron slag.....
Iron wire formulæ.....400
Irrigation, Indian.....158
Ivory stains 400

J

Jamestown, the great pier..*289, 290
Japan, education in..... 61

K

Karawanken tunnel.....*156
Kerosene-driven torpedo boat...*405
Kefir and Yohourth.....334
Kinematic apparatus, Newman's.*120
Klondike, geology of.....410
Knossos, excavations in.....*34
Kobe's large wharves..... 64
Kronprinzessin Cecilie *337, 344

L

Labor, economical utilisation....270
Labor's share.....147

Lace making in Nottingham...387
Lamp, Moore's... 48
Lamps for alcohol...*180
Lead pencil eraser... 16
Lead varnish... 16
Leaves, coloring matter of... 80
Lice, preventive of plant... 32
Life, artificial...331
Lifting, ancient methods of...*172
Lightning, balloons and...103
Lines, preserving fishing... 21
Liniment for burns... 64
Lithium, anhydrous protoxide... 46
Locomotive, high-speed... 16
Locomotive, the modern...*157
Locomotives, new mountain...*73
Locomotive for steep grades...368
Locomotives, Mallet...*20
Locomotives, steam or electric...298
Locomotives and cars, increased size of... 16
Louse poison, blood... 32
Luderitz engines... 16
Luminous plants and animals...115
Lusitania's boilers...336

M

Magnetic axis of the earth...143
Magneto, speed control for...*198
Man, rise of...*152
Manometric apparatus of fish...*301
Map of U. S., big... 55
Mapmaking and topography, history of ...*116, 132
Mars, canals of...*76
Mars, climate of...383
Mars, how observed...262
Martian signaling...137
Measurement, science of...126
Meerschaum ...196
Mercury vapor lamps...391
Metal-working machinery census 159
Metals, melting points of...331
Metalliferous veins, problem...403
Mica ...338
Micrometer microscopes ...388
Mines, water in anthracite...118
Mining, possibilities of hydraulic ...135
Mirror, concave... 48
Mirrors, copper...194
Modeling wax... 64
Molding with a group of cores...404
Monazite mining...247
Monitors, control of...119
Monsoon, mechanism of...315
Mont Blanc, astronomy on...335
Mont Blanc railway... 80
Moore's tube lamp... 48
Mosquito extermination...155
Moth exterminating powder, preparation of... 41
Motor, the interpole...101
Motor searchlight...*36
Motor starting devices, automobile ...*68
Mountain summits, meteorological phenomena on... 31

N

Navigating without horizon...405
Niagara Falls, money value of... 64
Nile-Red Sea railroad... *8
Nitric acid from air ...*393

O

Observatory, aeronautical... 24
Oil, neat's foot...192
Oil wells, shooting...307
Oil colors, medium for... 32
Oil fields of U. S...395
Okapi, the...*145, 146
Optics ... 48
Ore concentration with oil...*341
Ore, titaniferous in Wyoming...118
Organs, manufacture of...365
Original research...243
Ostrich industry, African...259

P

Paint for tin roofs... 32
Pan pipes ... 48
Panama canal progress...*353, 358
Panama half a century ago...386
Pandemics, early... 55
Paper pulp from bamboo... 11
Paris automobile show...*396
Paris metropolitan station...*40
Pearl industry in U. S...231
Peat deposits ... 64
Peat, for heating and power production ...362
Peat, novel uses of... 23
Peat products...111
Pendulum, the gridiron...*199
Photodynamic phenomena...115
Photographic plate testing...154
Photographic sensitiveness...*340
Photography, color...*217
Physical and psychical conditions.163
Piano strings, steel, to harden... 96
Pier at Jamestown...*289, 291
Pigeons, carrier, on Congo...375
Plagues ... 55
Plant breathing...255
Plaster, bronze imitation in... 64
Plaster, gypsum... 18
Poisonous shellfish...256
Pollination ...302
Portable fan... 47
Potassium chloroplatinite...199
Power plant tests, interpreting..374
Problems, unsolved, in ship design ...122
Protein ...208
Prussian railroad tests...*376
Pseudomorphs ...48
Pupin deep-water cable...*241, 248
Putty for floor boards...400
Pygmies, African... 9
Pygmies of the world... 90
Pyrites and sulphur...411
Pyrites, pseudomorph... 48
Pyrometer, electric metal testing ...*297

R

Radio-activity ... 59
Radium action ...288
Radium, atomic weight of...327
Radium, origin of...271
Radium's parentage... 59
Rails in streets, machine for laying ...*121
Rails, standardizing of...128
Railroad across Bernese Alps...107
Railroad bridge in Africa...*204
Railroad, Nile-Red Sea... *8
Railroad tests in Prussia...*376
Railroads of the world in 1907.. 50
Railway, electric, Munster Schlucht ... 16
Railway, Mont Blanc... 80
Rainfall, how absorbed...265
Rectifier, electrolytic... *5
Reitfontein rounded pebbles... 48
Rise of man...*152
Riveting, hydraulic, on the "Mauretania" ...*388
Roman cities of Northern Africa, *225, 232, 234
Roquefort cheese ... 51
Rubber-producing plants of Brazil ... 32
Rubber, recovering waste...345
Rubber tree in Sicily... 48
Rust, iron, electrolytic cause of.. 74

S

St. Swithin's day... 95
Salol liniment... 64
Salve for burns... 63
Sardine packing in Norway...383
Science, abstract and applied...214
Science, its gradual advance...142
Sea defenses, reinforced concrete.*66
Sea level variation...286
Sea water action on concrete...378
Sea waves, forms and energy of. 75
Searchlight, self-propelling...*36
Seed, evolution of the...94, 106
Selenium ...409
Seringueiras ... 32
Shackleton's expedition to Antarctic ...*104
Shear leg...*36
Ships, unsolved problems in..102, 122
Shipbuilding, development of Japanese ...130
Shipping, German, enterprise...166
Shunk, W. F... 43
Sight ... 48
Silver plating ...176
Silver plating processes...192
Silver, recovery of... 84
Slag car, new type of...*61
Slide-wire bridge, home-made...*244
Smelting iron ores by electricity. 48
Smelting plant, hydro-electric...
Soil surveys, use of...221
Solar energy and engines...185
Soldering appliances...*373
Soldering and soldering processes *7
Soul houses in Egypt...*380
Sound distinguishing...304
Soup tablets, bouillion... 48
South pole, expedition to...*104
Spark method for grading steel.*196
Star catalogue...208
Star distribution...287
Stars, spectroscopic phenomena in 27
Stars, their remoteness...235
Starfish, photographing...*252
Station, St. Michel...*40
Steamship, day of, over... 48
Steel alloy forging...311
Steel, casehardening of...322
Steels, chrome and nickel...336
Steel grading by spark method..196
Stone, great use of...285
Structural material... 64
Submarine boat progress...167
Submarine, first German...*84
Subway, air in...*164, 165
Subways Saint Michael Station.. 40
Sulphur and pyrites ...411
Sun prism, Coizi's...*254
Sun's motion relative to ether..*412
Sun's temperature...*261
Sunlight, effect on germs...171
Superheaters for marine boilers..186
Swallows as insect destroyers.... 47

T

Tantalum ...215
Tebessa, ruins at...*113, 114
Telectroscope, the Senlecq...*372
Telegraph circuit, longest... 16
Telegraphy, electric wave...*189
Telegraphy, progress in wireless 75
Telephone cable, Pupin...*241, 248
Telephone, wireless...*37
Telescope, the...191
Temples, Greek... 67
Timber, dead, in national forests.259
Timber, preservation of... 71
Timber protection... 311
Timber, steaming of...323
Time signals, wireless... 16
Tin electrodeposition...278
Tin, recovery of... 23
Tin roofs, paint for... 32
Tin varnish... 32
Tomatoes that imitate fruit...*153
Tombac ... 64
Torpedo, guided by electric waves ...*100
Torsiometers applied to turbines.*187
Trains, cable-assisted...*216
Trajan's column... 31
Transformers, series, errors which may arise in ... 16
Transmutation of matter... 27
Tree planting in Pennsylvania... 75
Tube lamp, Moore's... 48
Tunnel, Battery, New York...284
Tunnel, the Karawanken...*156
Tunnel ventilation... 21
Turbine, the marine steam... 91
Turbine, a new gas...*237
Turbine coal consumption...387
Turbines, loss of efficiency in...378
Turpentine from waste wood...194

V

Vacuum produced by slaked lime.352
Valves for gas engines...340
Vanadium, notes on...375
Varnish for cardboard...112
Varnish for cartonnage work... 96
Varnish for wicker work... 6
Varnish, quick-drying... 48
Venomous fishes...*12
Ventilation, tunnel... 21
Verde antique finish...*347
Vision ... 48

W

Wages and food prices...210
War vessels, development of armored ...*131, 151, 170, 178, 205 218, 238, 245, 266, 270 291, 308, 332, 342
Watch and clock notes...240
Water in granite...339
Water production, mineral...182
Waterproofing, scientific ...389
Wax grafting... 16
Wax modeling... 64
Weather problems, new...*184
Welding of metals, autogenous.. 38
Welding powder, iron to steel...374
Wells that feel the sea...147
Whale, model of...*161, 162
Whalebone, substitute for... 74
Wheat, analysis of... 39
Wheat, the story of...304
Wicker work, varnish for... 6
Wireless telegraph apparatus...*101
Wireless telegraphy tuning...406
Wireless telegraphy...86, 199
Wireless telegraphy, transatlantic ...319
Wireless telephone...*37
Wireless telephony, novel...150
Wireless time signals... 16
Wood, effects of moisture on...182
Wood, strength and stiffness of.. 20

X

X-rays of respiration...*285

Z

Zoological park, Hagenbeck's.*81, 88
Zoology, progress of...146